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"CONSERVATION OF WILD LIFE THROUGH EDUCATION."

VOLUME 21 SACRAMENTO, JANUARY, 1935 No. 1

TABLE OF CONTENTS

Page

A SUMMARY OF THE LIFE HISTORY OF THE CALIFORNIA SARDINE AND ITS INFLUENCE ON THE FISHERY *Frances N. Clark* 1

SARDINE CANNERY METHODS IN CALIFORNIA *Richard S. Croker* 10

SAN FRANCISCO TRAWL FISHERY *G. H. Clark* 22

THE CRAB FISHERY OF CALIFORNIA *J. B. Phillips* 38

THE HARVESTING OF KELP IN CALIFORNIA *W. L. Scofield* 61

THE CALIFORNIA OYSTER INDUSTRY *Paul Bonnot* 65

EDITORIALS AND NOTES 81

REPORTS—

STATEMENT OF INCOME 89

STATEMENT OF EXPENDITURE 90

EIGHT YEAR RECORD OF DEER KILL IN CALIFORNIA Between pages 92–93

HUNTERS KILLING TWO DEER, 1934 93

VIOLATIONS OF FISH AND GAME LAWS 94

FRESH FISHERY PRODUCTS 96

A SUMMARY OF THE LIFE-HISTORY OF THE CALIFORNIA SARDINE AND ITS INFLUENCE ON THE FISHERY *

By FRANCES N. CLARK

Individually the sardine is one of the least conspicuous of the fishes swimming Pacific waters. It is not a rapid swimmer, that it travels great distances is not readily apparent, it seldom takes a hook

* Contribution No. 145 from the California State Fisheries Laboratory. August, 1934.

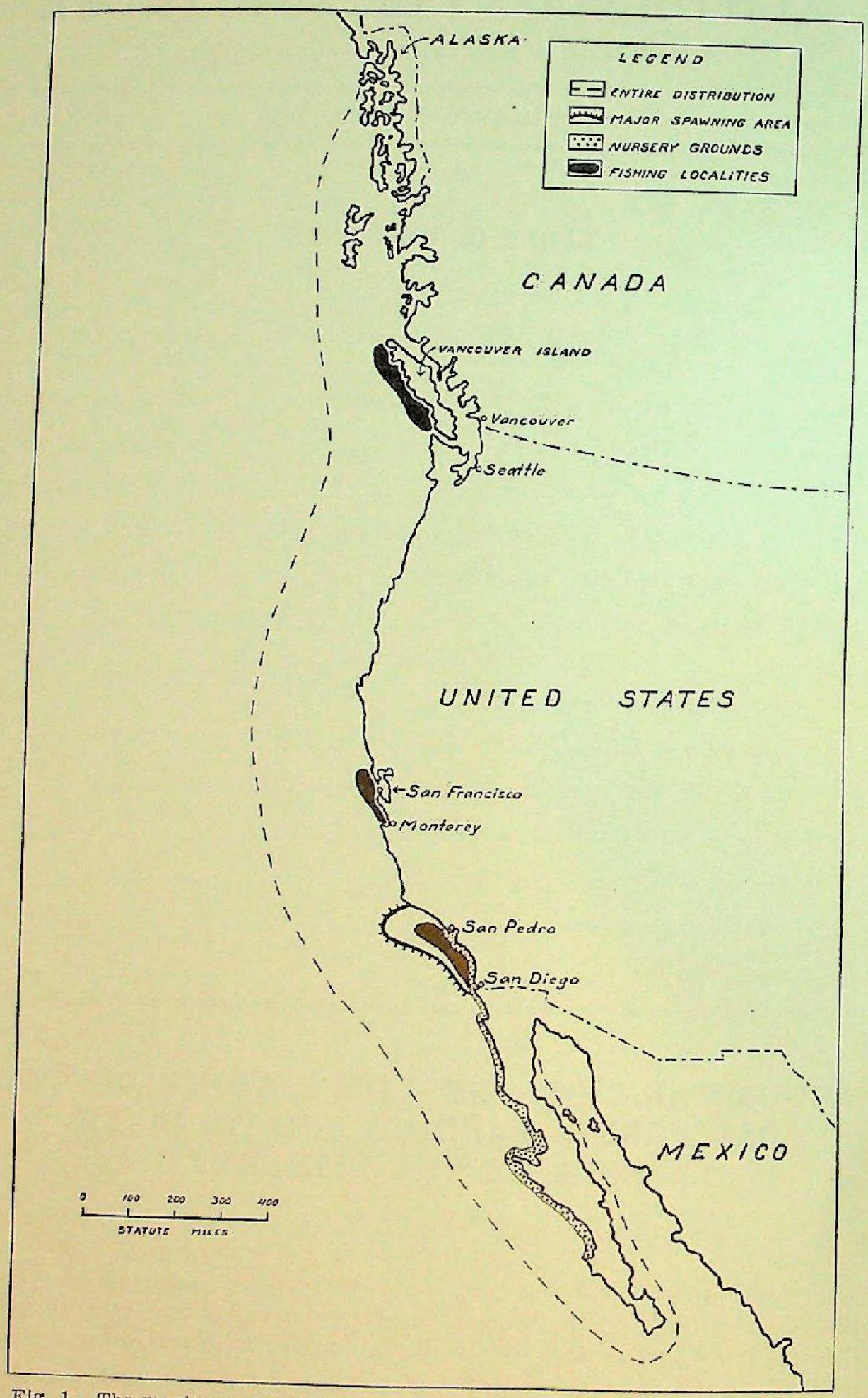


Fig. 1. The maximum distribution of the California sardine, the major spawning area, the chief nursery grounds, and the fishing localities.

and is not fished by sportsmen, it does not prey on other fishes and consequently is not condemned as an enemy of more desirable species. But collectively, the sardine population plays the leading role in the fisheries of the State. The tonnage of sardines landed in California each year is more than twice as great as that of the combined catch of all other species of fishes, mollusks and crustaceans. In addition, the tuna, mackerel, barracuda, and yellowtail fisheries are largely dependent on sardines for bait and thousands of tons of sardines are used annually as bait by sport fishermen. Furthermore, sardines are an important source of food supply for many species of fish. Because of the basic importance of sardines, the California Division of Fish and Game, through its Fisheries Laboratory, has made a detailed study of this fish and its fishery. The results of this study, begun in 1919, have brought to light much of interest about the life-history of the species.

The California sardine, *Sardina caerulea,* a coastal form, is not found more than three or four hundred miles from shore, usually less than one hundred miles. It is a true sardine and is not to be confused with the herrings along our Pacific coast, nor with the sardines on the Asiatic side of the Pacific. It is a different and larger species than the Japanese sardine, from which it is completely separated geographically. The California sardine has been taken as far north as southern Alaska, off the outer coast of Vancouver Island, along the entire coast of Washington, Oregon, California, Lower California, and into the Gulf of California. (See Fig. 1.) Occurrences in Alaskan waters are spasmodic and sardines are only occasionally reported from these regions. During the summer months, July to September, they are present off Vancouver Island in numbers sufficient to support a good-sized industry, and scattered individuals have been found in this region the year around (Hart, 1933.1). Not enough sardines are utilized in Washington and Oregon to indicate in which season the greatest abundance occurs. In California some fish are found throughout the entire year, but sufficient fish to support a major industry are present only during the fall, winter and early spring. Off the coast of Lower California the sardines appear to decrease in abundance, especially the larger sizes, and these waters mark the southern extension of the sardine's range.

Spawning takes place between February and August with a maximum in April and May (Clark, F. N., 1934). Each female produces from 100,000 to 300,000 eggs per season, but the mortality rate of eggs and young fish is very high and only an infinitesimal number of these eggs survives to adulthood. Sardine eggs have been found as far north as San Francisco and south off the coast of Lower California, but four seasons of oceanographic work show that the center of spawning lies between Point Conception and San Diego, within 100 miles of shore, chiefly outside the Channel Islands (Scofield, E. C., 1934). The eggs are fertilized after extrusion and float freely in the upper 25 fathoms of water. The eggs hatch in three days. The tiny, transparent larvae, eventually reach the chief nursery grounds, the sandy beaches of southern and Lower California. They begin to school when about 1½ inches long and 2 months old.

Young sardines have been found along the coast of California from Eureka to San Diego, down the entire coast of Lower California,

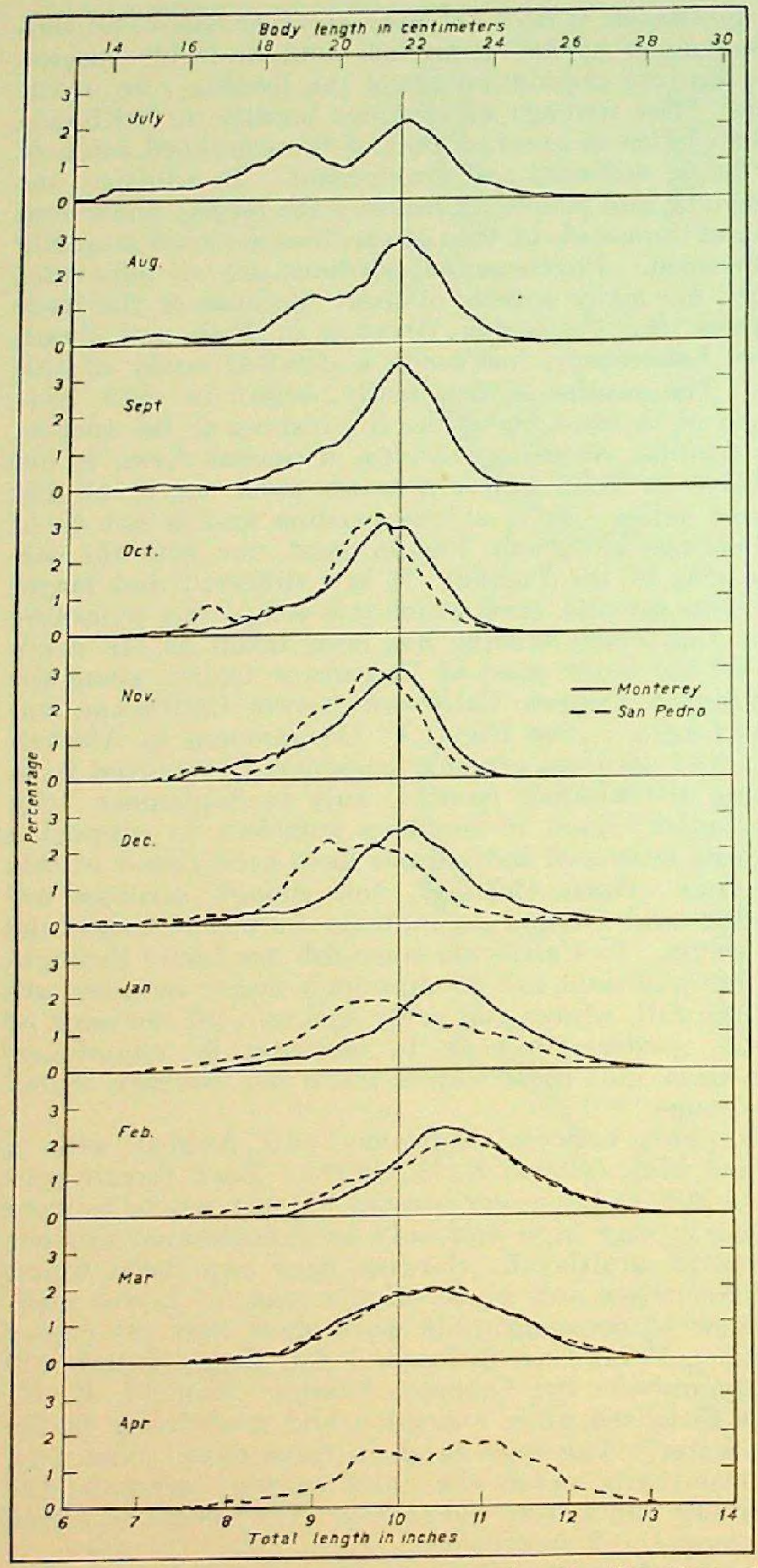


Fig. 2. Length frequency polygons showing the sizes of sardines taken each month of a sardine season at Monterey and San Pedro. Each monthly frequency was derived from an average of ten seasons' data. Body length is from the tip of the jaw to the base of the tail fin; total length from the tip of the jaw to the end of the tail.

and into the Gulf of California. How much the nursery grounds along the southern coast of Lower California contribute to the adult sardine population found off the coast of California is not known. It seems probable, however, that the majority of the adults entering into the California commercial catch is reared along the beaches of southern California and the northern part of Lower California.

Small sardines from one to two years old are used extensively for bait and are canned at San Diego in a "quarter-oil" pack (Godsil, 1931). When two to three years old, at sizes between $7\frac{1}{2}$ and $9\frac{1}{2}$ inches, the fish mature for the first time and appear in the commercial cannery catch at San Pedro and to a lesser extent at Monterey (Clark, F. N., 1934). These fish, now adults, play an important role in the California fishery for seven or eight years and may reach a maximum age of ten to fifteen years.

The sizes of sar-

dines in the cannery catch at both Monterey and San Pedro undergo a definite change every fishing season. This is shown graphically in figure 2. This figure gives an average picture of the size distribution to be expected in each month of a sardine fishing season. It was constructed by averaging the monthly catches over a ten-year period. Very few fish smaller than 8 inches are ever taken in the catch. At Monterey from August through November over half of the fish are less than 10 inches in length. In December larger fish begin to appear and in January, February and March the majority of the catch is composed of fish larger than 10 inches. Exactly the same size change occurs each season at San Pedro also, but about one month later.

Although the sizes of sardines taken at Monterey and San Pedro exhibit the same changes throughout each season, certain differences are also evident. During the fall months and through January more large fish are present at Monterey than at San Pedro. By March the sizes for the two localities are practically identical.

Figure 2 is a composite picture and represents the conditions which exist in an average season. Individual seasons vary from this average to some extent, but the change from smaller fish in the fall to larger fish in the winter occurs every season at both localities, and to a lesser degree at San Francisco. At San Francisco the fall fish are somewhat larger than at Monterey but the winter fish for all three localities are almost identical in size during any given season.

Individual seasonal differences in size result from the presence in the sardine population of exceptionally abundant year classes (Higgins, 1926; Scofield, W. L., 1926.2; Thompson, 1926.1; Clark, F. N. 1931). Fish composing these abundant groups enter the fishery and increase in size from year to year. They first influence the fall fishery for two or three years, causing a season of small fish first, the next year larger fish and the third year still larger fish. In exceptional cases an abundant year class has dominated the fall fishery for four successive seasons. In such instances in the fourth year the fall fish are unusually large. After two to three years an abundant year class has grown to sizes no longer present in the fall population but appears with the winter sardines. This change does not take place suddenly but is brought about by a gradual shift from season to season. The appearance of an abundant group in the winter fishery causes the sizes of the winter fish to vary in the same manner as in the fall. First the winter fish are smaller than average and then increase in size from year to year. After eight to ten years an abundant group has run its course and no longer influences the sizes of fish caught. The history of any normal or less-than-normal group is the same as that of an abundant year class, but only the abundant groups can be easily traced through the fishery. These abundant year classes do not appear in the fishery at constant intervals. During the past fifteen years (1919–1934) they have occurred in successive years and also at two and three year intervals.

The changes in size of fish from the smaller, fall fish to the larger, winter fish result from the movements of sardines up and down the California coast. Young fish reared on the nursery grounds of southern California and northern Lower California work northward during their first and second years. The spring bait fishery at San Diego appears to be composed in part of fish which have been reared at San

Diego and in part of fish which have been reared to the southward. At approximately two years of age (7½ to 9½ inches in length) sardines of any year class are first taken in important numbers in the San Pedro fall fishery. Some fish of this size and age also appear at Monterey in the fall of the same year but the majority does not go as far north as Monterey until one year later. These fish are adolescent and in general exhibit the same behavior as do the adult sardines. During the summer of each succeeding year a given year class moves a little farther north along the California coast and makes a return journey to the south during the fall and winter. The more extended northward movement each succeeding summer causes a correspondingly later appearance of the older fish at any given point on the southward journey. The larger and older fish do not appear off Monterey and San Pedro until the winter months. Their return to Monterey occurs about a month earlier than to San Pedro. Just how far north any given year class moves in each succeeding summer we have not learned as yet, but all evidence at hand indicates that the largest and oldest fish reach British Columbia sometime between July and September. Perhaps these fish constitute stragglers from the main population but more probably the majority of them again returns to southern California waters in the spring to deposit their eggs on the main spawning grounds south of Point Conception. This north and south movement seemingly is a feeding and spawning migration: northward during the spring and summer, when the sardine is feeding and storing up fat, and southward during the fall and winter with the sardine still feeding and the sex products maturing preparatory to another spawning in southern waters.*

Because of the variations in the successful survival of spawn from season to season, the adult sardine population is subject to fluctuations in abundance. Two or three successful spawnings following in close succession produce, a few years later, an increase of adult fish. Conversely, a few years of poor survival cause a scarcity of older fish in succeeding years. A period of successful spawning occurred between 1922 and 1926 and these abundant year classes maintained the intense fishery occurring up to and through 1929 and 1930. Following 1926 only two successful and one fairly successful spawnings have occurred and the present fishery is drawing on a population which in general has been depleted because of the poor survival of young fish. A fishery as intense as that of 1929 and 1930 consequently will place a much more severe strain on the present population than the intense fishery of former years. Such a strain occurred with the heavy fishery of the 1933–1934 season. To assure the maintenance of a breeding stock adequate for the perpetuation of the sardine population at its present abundance, the fishery must be regulated with care. This involves a continuation of the present research program and an intelligent application of its findings to the practical regulation of the fishery.

* The evidence to substantiate these conclusions about the sardine movements is: the apparent homogeneity of the population along the entire Pacific coast (Hubbs, 1925; Clark, F. N., 1931; Hart, 1933.2); the greater abundance of smaller, younger fish in the south than in the north as shown by the bait and quarter-oil fisheries and the San Pedro and Monterey cannery catches; the occurrence of the largest, oldest fish during the summer in British Columbia, their appearance first at San Francisco in the early winter, then at Monterey and last at San Pedro and San Diego in the late winter (Higgins, 1926; Scofield, W. L., 1926.2; Clark, F. N., 1930.2; Hart, 1933.1); the maturation of the sex products at approximately the same rate as the southward movement followed by the first appearance of spent fish to the northward (Clark, F. N., 1934); and the location of the main spawning grounds south of Point Conception (Scofield, E. C., 1934).

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SARDINE CANNING METHODS IN CALIFORNIA*

By RICHARD S. CROKER

(Photographs by D. H. Fry, Jr., and author, San Pedro, February, 1934)

INTRODUCTION

California sardine canning methods have undergone considerable changes during the last five years. Until recently it was the universal practice to fry the sardines in tanks of cottonseed oil before placing them in the cans. The oil fry resulted in an excellent pack when the oil was fresh, but after a few hours' use it became stale and impregnated with the oil that cooked out of the fish themselves. Thus the major part of a day's run consisted of sardines cooked in virtual fish oil. These fish were sometimes bitter and invariably caused an "after-taste." The product was suitable for export to certain markets, but the domestic and higher class foreign trade would have nothing to do with it. Due to the recent curtailment of export markets, it became necessary for the canners to experiment with cooking methods that would make the California sardine acceptable to the American housewife. During the last few seasons several suitable ways of replacing the oil fry have been evolved so that at present the sardine as packed in California is a quality product.

The canning of sardines (*Sardina caerulea*) is carried on at four points in California: Monterey, San Pedro-Long Beach, San Francisco Bay and San Diego. The latter place specializes in a fancy pack of small sardines in quarter-pound square cans. The other centers pack on a much larger scale, using adult sardines, 8 to 12 inches long, and employing a great variety of can sizes and shapes. The familiar one-pound oval can early became a favorite and is still the most popular container. Recently, however, three sizes of round cans have been gaining favor. The one-pound tall can has come into use as a competitor of salmon and mackerel, and the 5-ounce and 12-ounce tall cans are increasing in popularity. Half-pound oval cans, half-pound square tins, one-pound flats, and a few other sizes are also used to some extent.

The following description of packing methods concerns itself principally with conditions in effect at San Pedro during the 1933–1934 season. Similar methods are in use at Monterey and San Francisco. The description of "quarter-oil" canning deals with methods in use at San Diego in 1933. The canning season at San Francisco and Monterey extends from August 1 to February 15. At San Pedro canning is carried on from November 1 to March 31. Small sardines are packed at San Diego principally during March, April and May, although the quarter-oil canning season is variable and not limited by law as are the seasons for adult sardines.

* Contribution No. 143 from the California State Fisheries Laboratory. October, 1934.

The author wishes to express his appreciation for the assistance rendered in the preparation of this report by the members of the fishing industry, especially Mr. Alfred Luthi of the American Can Company.

Although there are a great many variations in method, the general process of canning sardines can be described briefly as follows: The fish are beheaded, cleaned, packed raw in cans by hand, and given a steam cook in the open cans. The lids are then sealed, the cans washed and given a final cook in retorts. The following pages discuss details and variations of the process.

ARRIVAL OF THE SARDINES AT THE CANNERY

Fishing for California sardines is carried on from 3 to 100 miles from the canneries. As soon as a boat has secured its load, it returns to port. All sardines used for canning are unloaded at the cannery within 12 hours of being caught; sometimes a few of the fish are still alive when delivered.

A series of hoists and flumes carries the sardines from the boat to cannery tanks, containing salt water. In some canneries the sardines pass through a "scaling machine" on the way to the tanks. This device consists of a large revolving drum or cylinder made of square wire mesh. The fish enter one end of the drum which is inclined slightly, and are carried to the other end by gravity. During their passage through the cylinder, they are rolled against the wire and each other continually and are subjected to streams of water from a series of jets. As their scales are but loosely fastened, the fish are fairly well scaled by this operation. In all canneries the fish pass through a scaler after being cleaned, regardless of whether they have gone through one when they first entered the plant. (See Fig. 3.)

The holding tanks are equipped with several gates along one side at the bottom. The men in charge of the tanks can open these gates and flush the sardines through flumes to the cleaning tables or cutting machines.

CUTTING AND CLEANING THE SARDINES

At some canneries, the sardines are cut and cleaned by hand, in others by machinery, and in a few some of the sardines are cut by hand and some by machine. The fish are all cleaned the same way, regardless of what style pack they are intended for. However, those destined for small cans are cut shorter than those for the one-pound cans.

The cutting room of a cannery where the sardines are prepared entirely by hand presents an interesting sight. The holding tank, which is several feet above the floor, extends almost the entire length of the room. Adjacent to it, on the floor, is a row of cutting tables. Six to ten men or women work at each table, standing along both sides. Most of the cutters are Japanese or Filipinos. In the middle of each table and extending its entire length is a trough. The tank man keeps this trough filled with sardines by opening a gate on the tank from time to time. Along either side of the table is a wide board upon which the workers cut the fish after removing them from the trough.

The cutter uses a fairly dull knife. First he severs the head, and then before the cut is quite complete he pushes the head away from the body with his knife. This pushing motion carries most of the viscera away with the head. He then places the front end of the fish against a small upright board which is in front of him on the table,

and cuts off the tail a given distance from the board, depending upon what size can is being used. Sometimes the tails are left on the fish which are to go into oval cans. The first cut has been made far enough behind the head to eliminate most of the intestines and the remainder are pulled away with the head. Usually parts of the gonads (ovary or testis) remain in the fish, but as these are edible no harm results from leaving them.

At intervals along the cutting board there are holes connecting with a flume that leads to the "fertilizer" plant in another part of the cannery. Into these holes, the cutters shove the heads, tails, viscera, and all soft or otherwise unsuitable fish. The offal is manufactured into meal and oil which are valuable by-products.



Fig. 3. Scaling machine in a California sardine cannery. The cut fish pass through the inclined revolving drum, which removes scales and particles of viscera. The pipe is perforated so that streams of water play on the fish. The conveyor at the right carries the fish to the packing room.

At some canneries, the cutters are paid on a time basis and at others they are paid according to the number of fish they cut. The piece-workers have boxes which they fill with cut fish and carry to a checker who inspects the sardines and punches the cutter's piece-work card. The checker dumps the fish into a flume that leads to the scaler. The cutters who work by the hour place the fish they have cleaned into a flume which carries them to the scaler. This machine is similar to the one mentioned above. (See Fig. 3.) It removes practically all of the remaining scales and the bits of viscera that adhere to the fish. The sardines are now ready for canning and are carried on a belt conveyor to the packing room.

The cutting machines used in other canneries are strikingly different in appearance from the hand-cutting tables, although they perform the same work. The machines, eight or more in number, depending

upon the size of the cannery, are located along the base of the holding tank. Four women, usually Japanese, work at each machine. The women's job is to place the sardines in the machine which does the cutting. In front of the two women who stand on one side is a trough into which the man on the tank sluices the whole sardines. At some machines as the one shown in figure 4, one of the women operates the gate lever. Just beyond the trough, there is a moving belt with grooves into which the women place the sardines they take from the trough. The belt carries the fish under a pair of rotary knives, one of which severs the head and the other removes the tail. As indicated by the position of the slit in the belt shown in figure 4, the head cut is made some little distance posterior to the head. Each machine is in duplicate, that is, it has two troughs, two parallel belts and two pairs of knives. The severed heads fall into a flume, carrying most of the viscera with them. The tails fall into the same flume, which leads to the fertilizer room. The bodies drop onto a belt conveyor which carries them to the scaler and thence to the packing room.



Fig. 4. Looking down on a sardine cutting machine. The belt carries the fish under a battery of rotary knives. The fish storage tanks are to the left of the woman in the foreground.

If there is anything to choose between the two methods of cutting as far as quality of output is concerned, it may be said that the hand cleaners remove the viscera a trifle more thoroughly, but that the cuts made by the machines are somewhat neater and the resulting pieces are more uniform in length.

At least one of the northern California canneries employs vacuum type cleaning machines, which are a recent development. Hand labor is reduced to a minimum. The sardines pass through this machine with great rapidity and emerge with the heads and tails cut off and the viscera removed by suction.

At another northern cannery, a rotating drill is used to remove the viscera after the heads are severed. The automatic drill is inserted into the visceral cavity with a twisting motion that cuts the intestines loose from the body. A stream of water running through the center of the drill washes out all the loose material. This type of cleaning

machine, which is patented by the cannery, is said to be the most efficient in use at present.

Once the sardines are cut and cleaned, further processes differ from plant to plant and with the different types of pack.

PACKING ONE-POUND OVALS

It must be noted at the outset that no two canneries employ exactly the same practices in packing and cooking. At nearly all canneries, the sardines are given a "precook" before the cans are sealed, although the first cooking is not necessary for the "vacuum pack." Departures from the general method will be taken up at the conclusion of the following description of a typical "precook pack."



Fig. 5. Packing sardines in oval cans. The pieces of fish come to the workers in the wire baskets above the table.

The sardines go from the cutting room to "brine tanks" in or near the packing room. These tanks contain salt water in which the fish are kept until needed by the packers. Fresh water would soften the fish. The purpose of the tanks is to provide a surplus of cut cardines so that a steady supply is available to the packers.

In the packing room are one or more long tables at which women workers fill the cans by hand. Down the middle of each table runs a belt conveyor that carries the sardines from the brine tanks to the workers. The women can divert the stream of fish from the belt to the table as needed. In some plants, the fish are dipped from the tanks and placed in shallow wire baskets which are carried to the packers by a conveyor. (See Fig. 5.) In some canneries where it would be difficult to install conveyors, men carry the baskets of fish to the packers.

At some plants, the empty cans come to the packers on belt conveyors running either above or below the belt that carries the fish.

(See Fig. 5.) In other canneries, men bring the empty cans to the table in boxes which are placed alongside the packers.

The women packers are of all nationalities and are often the wives or other relatives of the fishermen. They, as well as the other cannery workers, also work on tuna and mackerel when those fish are being canned at the same plant.

The women work with great speed, albeit carefully, as they place the fish in the can, belly up, alternating ends so as to fill the can to the best advantage. It is the custom to arrange the fish in one layer, 5 or 6 to the can, depending upon the size of the sardines. At present the minimum number of fish per can is 4 and the maximum is 8. The packer places the filled cans on a platform above the table (see Fig. 5) until she has a specified number, usually 12 or 15. A checker inspects the cans, punches the packer's piece-work card and releases the cans onto a belt conveyor that carries them to the cooker. Before the cans reach the cooker, however, they have to pass the scrutiny of inspectors who cut off loose pieces and reject overfilled or underfilled cans. Balance scales are sometimes used by the packers or inspectors to make sure of the weight of doubtful cans.

The precooker is known as an exhaust box. It consists of an enclosed steam chamber, the length of which runs a belt conveyor to carry the cans. This conveyor winds back and forth in the cooker so that the cans make several circuits before emerging. Both ends of the exhaust box are open so that the cans can enter and leave. Live steam, under no pressure, heats the exhaust box to about 210° F. The cans take 20 to 35 minutes to pass through the cooker, the times varying at different canneries. In the exhaust box some of the moisture is cooked out of the fish, and the vacant spaces in the can become filled with live steam which condenses when the can cools after being sealed, and causes a vacuum. At the conclusion of the steam cook, the cans are inverted in order to drain off the moisture that has been cooked out of the fish. The conveyor makes a loop to tip the cans.

The cans now pass under the sauce machine which automatically inserts approximately two ounces of either tomato sauce or mustard sauce, as the case may be, into each can. (See Fig. 6.) The greater part of the pack is put up with tomato sauce. Each conveyor leads to a closing machine where the lids are put on the cans and sealed. Another belt conveyor carries the sealed cans to a vat of boiling water and lye wherein they are rinsed. Bits of fish have gathered on the can, which also collected some grease while passing over the lubricated slide on the closing machine. It may be noted at this point that because of the awkward shape of the oval can, belt conveyors or greased gravity conveyors are necessary for carrying them from one place to another—the oval cans will not roll in an ordinary gravity conveyor like the round tins.

After the rinse, the cans drop into large iron baskets with wheels, which when full are pushed into the retorts for the final cook. In the retort (see Fig. 7), the cans are cooked for 75 to 90 minutes at a heat of 240° F. under 11 pounds pressure, the time varying from one cannery to another. The aim is to give the fish a thorough, sterilizing

cook.* After the cans have been in the retort the desired length of time, a stream of cold water is turned on them. At the same time, the pressure gauge is slowly turned to 15 pounds to overcome the drop in pressure that the cold water would otherwise occasion. A sudden decline of pressure would cause the retort to collapse. The oval can presents a large flat surface, and if it were cooled at ordinary atmos-

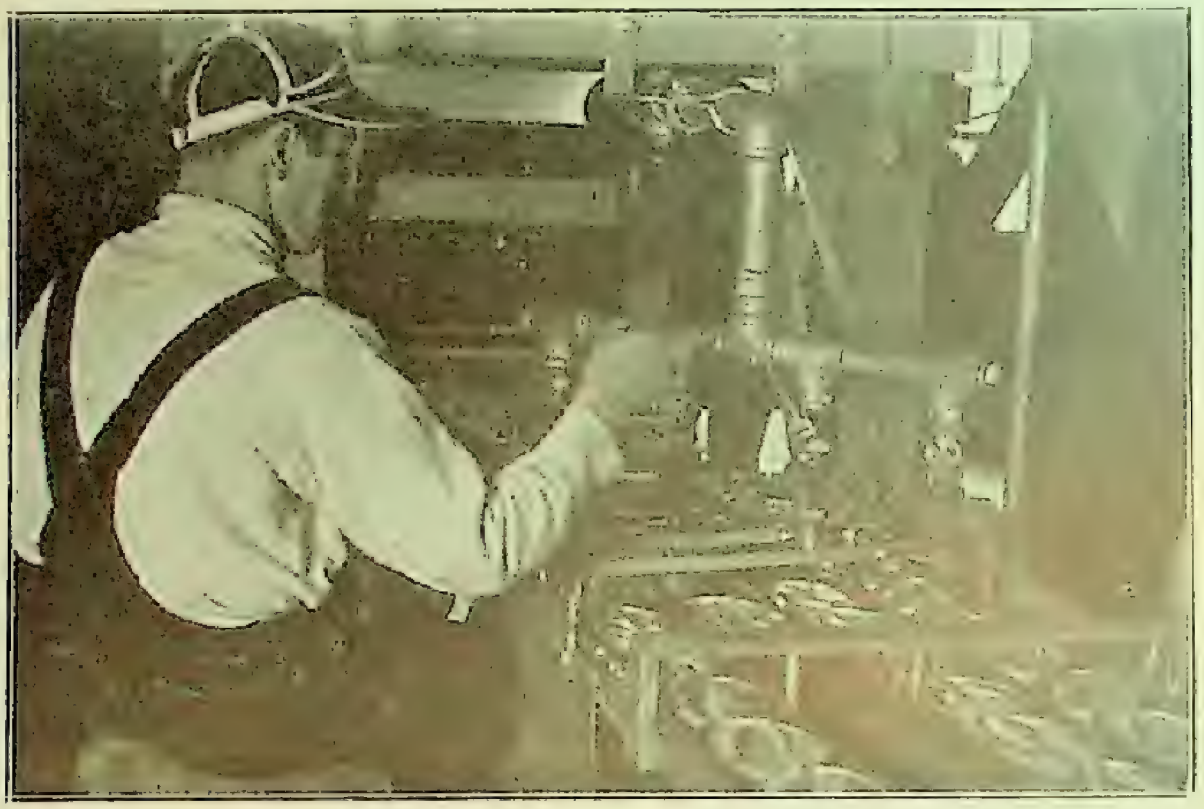


Fig. 6. The sauce machine. The open cans pass under the jets at a definite speed which allows two ounces of tomato or mustard sauce to run into each can.

pheric pressure it would burst, hence the stream of cold water in the retort. As the air pressure is increased the steam is turned off. After the water has stood in the retort for a few minutes the door is opened and the baskets are pulled out and wheeled to a storeroom for further cooling.

All that remain to be done now are labeling and casing. Sometimes the cans are dipped in a tank of lacquer before labeling. The lacquer not only retards rusting which otherwise would occur in damp tropical countries, but gives the cans a golden hue, desirable in certain markets. The labeling machine is an ingenious device. The cans are fed by hand onto a conveyor that leads to the labeler. Each can drops in an upright position onto an individual carrier that brushes part of the can against some glue and then spins it past a sheaf of labels. The glue picks up the outermost label, which is affixed as the can goes by. In order to be on the safe side, the label states the can's contents as 15 ounces. As a matter of fact the ovals average a full pound, net weight,

* The California Department of Public Health, through its Bureau of Cannery Inspection, has formulated certain regulations regarding minimum retort temperatures and length of cook. These regulations are based on the research work of Dr. Karl F. Meyer of the Hooper Foundation for Medical Research, University of California. All the canneries abide by the regulations, although some prefer to cook their fish longer than the law specifies. All retorting times given in this article are the minimum legal times, except that in the cases where some canners retort their fish longer than required, the maximum times are also given.

including sardines and sauce. The cans are carried on a short conveyor from the labeling machine to the case packers. These men place the cans in fiberboard or wooden boxes, four dozen to the case. The lids of the fiberboard boxes are glued shut, and the wooden cases are nailed and wired. The cases are either placed in the adjoining warehouse until needed or loaded directly into freight cars or trucks. The labeling and casing crew consists of 6 to 12 men.

As a variation from the above method of packing oval cans, some canneries subject the sardines to a brine bath after they have been cleaned. The pieces of fish are left for one and one-half to two hours in the brine tanks which contain a saturated salt solution. The salt removes the slime from the surface of the fish and draws out some of the blood and moisture. It is also claimed that the flavor is improved by soaking the sardines in brine.

At some canneries the cutters do not sever the tails of the sardines, as was mentioned previously. It is said that the tails help to hold the fish in place in the can during the first cooking, which often causes the fish to hump or bend.

The tomato or mustard sauce is added in a variety of ways. In some plants, all the conveyors from the one large exhaust box pass

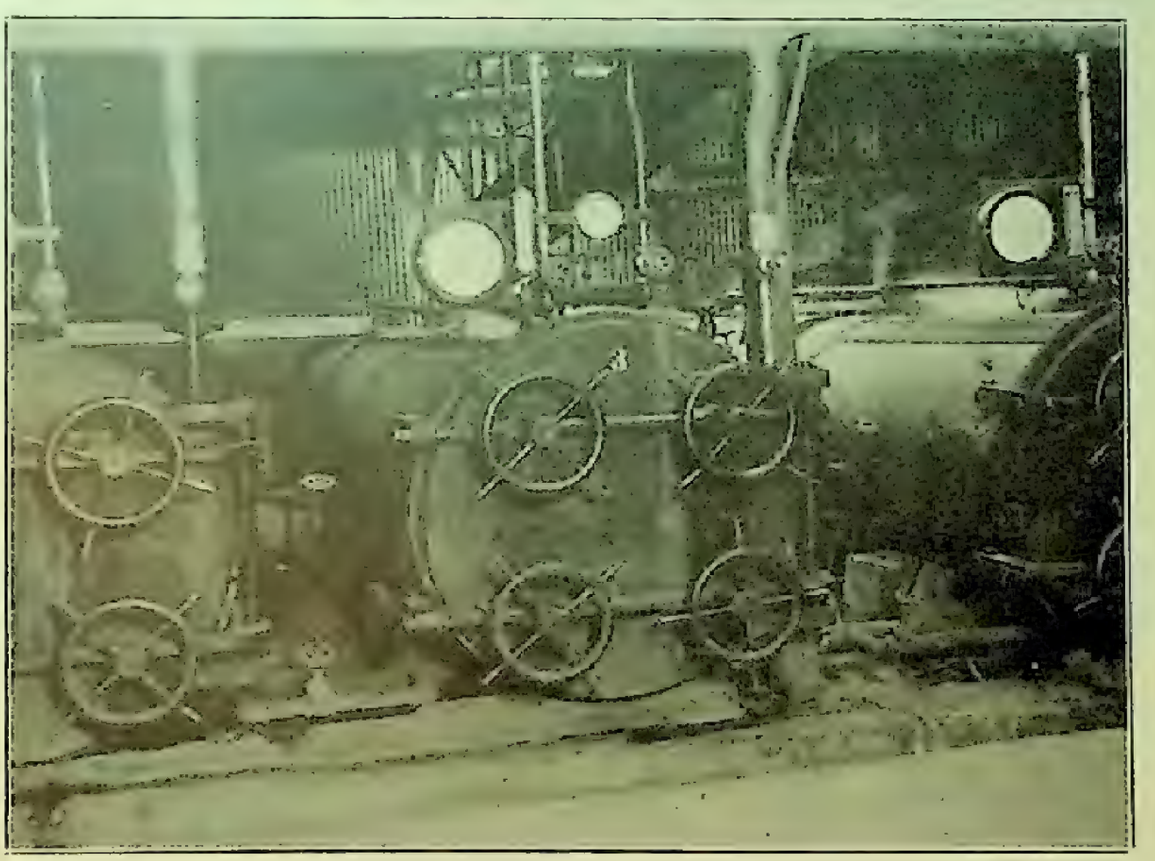


Fig. 7. The retorts where the sealed cans are cooked at a high temperature to sterilize the contents.

under one sauce machine, such as the one shown in figure 6, after which the cans are diverted onto a larger number of conveyors, each going to one closing machine. At other plants, the conveyor from each table goes to a separate exhaust box and closing machine, with one small sauce dispenser on each machine. At other canneries the sauce is

added either before the precook or after the cans have been but part of the way through the exhaust box. The sauce is usually, but not always, hot when placed in the cans. Some oval cans are put up without either tomato or mustard sauce. These cans are filled with hot brine after the precook.

Some exhaust boxes are heated to about 230° F. by gas flame. It is claimed that the additional heat results in a better cooked, firmer product.

Several canneries precook their sardines in a somewhat different manner than any listed above. At these plants, the packers place the filled cans in shallow wire baskets, two or three layers deep. The baskets are placed in wheeled racks which are pushed into the steam cookers, wherein tuna are processed at other times. In these cookers the cans are subjected to live steam under two pounds pressure for about 25 minutes. The racks are then removed, and the baskets are inverted over a wire screen for a few minutes. This allows the cans to drain without losing the fish. Tomato or mustard sauce is now added and the cans are given a brief cooking in an ordinary exhaust box in order to maintain the vacuum. They are then capped, washed and retorted in the same manner as described above.

One of the northern California canneries precooks its fish with radiant heat instead of steam. In this process, the fish are cleaned, brined and placed in the cans raw, as described above. The filled cans enter a series of ovens where the sardines are broiled for about 45 minutes at a temperature of approximately 450° F. After the precook, the cans are drained and hot tomato sauce is added. Sealing, washing and retorting follow. The cannery that developed this process claims that broiling results in firmer fish with less "after-taste" than steam cooked fish. The equipment is patented.

In order to prepare sardines for the "vacuum pack," they are soaked in saturated brine for one and one-half to two hours immediately after being cleaned. They go from the brine tank to the dryer. This device consists of a large, enclosed box through which a strong current of air is circulated by rotary blowers or fans. The dryer is kept at room temperature or higher. The fish enter one end at the top, from which point a belt conveyor carries them to the other end, where they drop onto another belt that carries them back, and then onto a lower belt, back and forth for an hour. They then emerge and go to the packing tables on a conveyor. In the vacuum pack there is no precook, hence the brining and drying to shrink the fish and make them firm.

The packing method is the same as for the precook pack. The filled cans pass under the sauce machine where the tomato or mustard is added. From here they go direct to the closing machines without passing through an exhaust box.

The first operation of the vacuum closing machine is to affix the lid, which, however, is not sealed tight but merely crimped. The can now goes into the vacuum chamber where it remains for five seconds. In this part of the machine a vacuum is maintained by suction pump. The air is sucked out of the can, leaving the fish and sauce in a vacuum. The lid is sealed tight while the can is still in the vacuum chamber. The can then emerges and drops onto the conveyor leading to the

washer and retorts. Figure 8 illustrates a vacuum closing machine. The cans are retorted 75 to 90 minutes at 240° F., as described above.

Opinion is divided as to the success of the vacuum pack for sardines. Proponents claim a superior, tastier product without the bother and expense of an exhaust box. Other canners claim that vacuum packed cans are loosely filled and that the fish is undercooked. They point out the nmber of swelled cans resulting from the vacuum method. 'However, the vacuum pack, as far as sardines are concerned, is a recent development and each season sees an improvement in the pack resulting in less rejected cans. The packers have no difficulty in disposing of their output, and after all that is the final test of quality.

Some canners have thought that perhaps the finest sardine pack of all would result from a combination of the precook and vacuum methods. Hence all eyes are turned to one of the northern canneries that adopted such a method in the fall of 1934. At this plant the unsealed cans are given a brief precook at a fairly high temperature after which they are drained and allowed to cool. Then sauce is added and the cans go to the vacuum sealer and then to the retorts. The product is said to be of excellent quality.

Sardines are packed in half-pound oval cans in the same ways as described above for one-pound ovals. The smaller cans are retorted 55 to 60 minutes at 240° F.



Fig. 8. A vacuum closing machine for oval sardine cans. A sealed can is emerging at the head of the runway in the left foreground.

PACKING SARDINES IN ROUND CANS

The output of sardines in tall, round cans represents several different styles of pack, *i.e.*, sardines in brine, in tomoato sauce, mustard, spices, cottonseed oil, and olive oil; and smoked sardines in the same variety of sauces. All these styles are packed in three sizes of cans; principally in 5-ounce and 16-ounce and to a lesser extent in 12-ounce containers.

Of the various styles, brine-packed sardines, both smoked and plain, are the most important. Nearly all the canneries pack sardines in brine on a quantity basis, whereas a few plants put up the other products more or less as specialties.

The following description applies to brine-packed sardines in their simplest form. The fish are cleaned and cut, as described above. They are cut to about the same length as the height of the can. The packers fill the cans by hand with raw, unbrined fish, placing the fish on end. Three pieces of fish fill a 5-ounce can, 4 or more longer pieces fill the larger tins. The full cans go on a belt to the exhaust box for the precook. Five-ounce cans are exhausted for 5 or 6 minutes; 12-ounce and 16-ounce tins for 15 to 35 minutes, depending upon the cannery. The cans then pass under a series of jets that fills them with hot brine. Inspectors remove loose pieces of fish and fins, and reject underfilled cans. At the closing machine, a topper compresses the sardines which sometimes project a little from the can after cooking. Sealing and washing follow, after which the cans drop into iron retort boxes. In the retorts, 5-ounce cans are cooked 55 to 60 minutes at 240° F. The 12-ounce and 1-pound cans are cooked 90 to 95 minutes at the same temperature. Cooling, labeling and casing complete the process.

Some canners soak the cut sardines in brine before packing. This process removes the slime and makes the fish firmer.

At a few plants, the packers place the full cans upside down in wire baskets. The baskets are run through the exhaust box and the cans drain as they cook. The cans are righted after the precook and are then filled with brine. The flavor and firmness of the sardines are said to be improved by this process, which, however, removes much of the oil from the fish.

At one plant, the exhaust box is in two sections. In the first part, the 1-pound cans are given a 15-minute steam cook. The second part is maintained at a temperature of 220° to 240° F., dry heat. The cans spend another 15 minutes in this section where some of the excess moisture is cooked out. Fish processed in this cooker are claimed to be firmer and tastier than those cooked in the ordinary steam box.

One cannery produces a "smoked" pack by adding a small amount of "liquid smoke" to the fish just before the can is sealed. The liquid smoke is a concentrated wood derivative. Retorting diffuses the smoked flavor throughout the can.

For the true smoked pack, the fish are actually processed in a smokehouse after soaking in brine for 1½ to 2 hours. The smokehouse is similar to the dryer used for vacuum-packed ovals. Smoke is produced by burning hardwood sawdust on an iron plate over a gas flame. The smoke is drawn into the smokebox by the blowers, as is sufficient hot air to heat the box to about 90° F. The fish require 1 to 1½ hours to pass through the smokehouse. After smoking, the packing methods are the same as described above.

The only difference in process between the brine-pack and other styles is that the brine is added to the cans after the precook, whereas the heated tomato sauce, mustard or oil is put into the cans before they enter the exhaust box. At some plants dry salt is added to the cans before precooking in place of the brine. Cooking blends the salt with the moisture of the fish to form the brine.

Many canners prefer to pack sardines in round cans rather than in ovals because of the lower cost of the former type of can, its greater ease of handling, and the less complicated closing and labeling machines necessary. It is possible to use one line for packing either "tall" sardines or mackerel, thus minimizing capital investment.

PACKING SARDINES IN QUARTER-POUND SQUARE CANS

The bulk of the California output of 4-ounce flat, square cans containing small sardines in oil is produced at San Diego. Young sardines, 5 to 7 inches long, are used for this style pack. These fish are known locally as "quarter-oils" or "quarters" because of the can used in packing them. The quarter-oils are usually caught within 10 miles of the canneries. As the small fish bruise and spoil readily, small loads only are accepted and the canners process the fish immediately upon arrival at the plant.

As soon as the fish are unloaded from the boat, they go to the cutting tables where they are beheaded and cleaned by hand. Care is taken to remove all the viscera. The fish are too delicate to permit any scaling operations, but most of the scales fall off during handling.

The cleaned fish are soaked in 65 per cent brine for approximately 30 minutes. From the brine tanks the sardines go to the dryer, which is similar to the one described previously. The air in the dryer is warmed somewhat above room temperature. About 45 minutes are required for the transit of the dryer.

The fish are next fried in a tank of cottonseed oil. The bottom of the tank contains water heated by steam pipes. A thick layer of oil floats on the water which is hot enough to hold the oil at a temperature of approximately 180° F. The sardines are placed in wire baskets which in turn are placed in the hot oil. A conveyor moving at a regulated speed carries the baskets from one end of the tank to the other. Upon arrival at the far end, the baskets are removed from the oil. The duration of the cook varies from 3 to 10 minutes, depending on the size and condition of the fish and on the state of the weather. In general, large fish require more cooking than small ones. Frying is intended to result in a pack of firm fish, consequently the softer sardines must be fried a little longer than those arriving at the cannery in the best of condition. When the air is damp the fish must be cooked more thoroughly than during dry weather or they will become soggy while cooling. After the oil-fry, the fish are allowed to cool and drain in the baskets for three hours or more before being packed.

The packers place the fish lengthwise in the cans by hand. Six to 12 fish, and rarely as many as 20, are used to fill each can, according to the size of the sardines. The usual number is 8 to 12. The packers reject all broken or torn fish, using perfect ones only. The filled cans pass through a steam cooker where they are exhausted for 2 to 7 minutes, depending again on the size of the fish. After the steam cook, the cans are drained and then filled with heated olive oil or, more rarely, with cottonseed oil. After sealing and washing, the cans are retorted for 75 minutes at 230° F.

Instead of, or in addition to, carrying the type of label used on round or oval cans, the square cans are wrapped in wax paper with the lithographed labels pasted on the outside. Most of the cans are intended to be opened with keys, in which case the keys are wrapped with the can.

Quarter-oil sardines are kept in storage three to six months before being sold. The flavor continues to improve during the first six months the fish are aged.

SAN FRANCISCO TRAWL FISHERY [1]

By G. H. Clark

(Photographs by the Author)

HISTORY

Dragging for bottom fishes in the region of San Francisco originated about 1876[2], when a net operated between two boats was used. This same gear, "paranzella net," was later used in the waters to the south as were other types of drag nets operated by one boat. However, this article will deal primarily with the drag net fishery of San Francisco, which industry has always caught the greatest poundage of bottom fishes.

For the first ten years, trawling operations were carried on in San Francisco Bay by small lateen sail boats and small nets that the boats could drag. All hauling was done by hand, and hard work it must have been for fish were very plentiful, although only the very largest and choicest were saved for the market, the rest being thrown overboard.

As the rich catches in the Bay began to decrease, the fishermen ventured out in their small boats to the open sea, where they were able to reap enormous catches between the Bar and the Farallon Islands. However, because of the long hauls to port, many of the "paranzella sets" of boats used a third boat to take the fish into market each day, the other two boats remaining at sheltered points near the fishing grounds. This occurred about 1880.

In 1885, the first steam trawler was used. It operated singly with outriggers on each side to which the warps were attached in order to hold the net open. Later other steam tugs were built and a large net was towed between two vessels on the ocean fishing grounds.

Soon after the steam trawlers had been fishing, a gasoline-powered boat was tried as a helper for one of the steam tugs. However, this was a failure because the engine did not have flexibility for fast running to the fishing grounds, then slow towing with a heavy load. By 1898, there were four steam tugs (two sets) operating the paranzella drag net out of San Francisco. These two sets were able to supply the market easily, for in summer months the catches were often too large for the demand and large quantities of good fish were dumped for lack of sale.

By 1903 the two companies engaged in the trawl fishery each had three boats. Two were used for fishing, the third as an alternate and carrier boat.

In 1909 a third set of boats started fishing a paranzella net. This was a pair of small boats propelled by gasoline motors. They operated

[1] Contribution No. 146 from the California State Fisheries Laboratory. October, 1934.

[2] Almost all of the early history of the paranzella nets and boats was taken from an unpublished manuscript by George Roger Chute.

with some success out of San Francisco for a year or two; then because of a merger of fish companies, they went to Monterey to continue operations.

By 1914 there were three producing companies fishing with the paranzella net with three sets of steam trawlers. In 1915 the gasoline boats which operated in 1909 were brought back into San Francisco trawling service, larger engines having been installed in them. In 1916 and 1917 three gasoline trawlers were built and another set went into fishing operations, making in all two steam sets and two gas sets. In the next two or three years several gas trawlers were put into operation in San Francisco. These boats remained in this service for various lengths of time, some being lost, others sold.

Gasoline trawling with paranzella nets was also carried on in the waters south of San Francisco off Santa Cruz, Monterey, Santa Barbara, San Pedro, and San Diego with some success, particularly for the California halibut. The State Legislature, however, outlawed the gear in the southernmost district of the State (from San Diego to the Ventura-Santa Barbara County line) because of destruction of small halibut.

From the period 1917–1922, when gasoline trawling out of San Francisco was at its height, to the present time (1934), all the existing boats have been converted to, and the new boats installed with, diesel power except one of the original steamers which is still in service. There are now (October, 1934) about 20 trawler boats in the San Francisco fleet and about seven sets of boats fishing. The remainder of the boats are alternates and carriers. All boats, with one exception, are diesel-powered, ranging in horsepower from 60 to 200 and in size from 56 to 72 feet long. In addition, there is one set of boats that operates out of Bodega Bay and sells some of its catch in San Francisco.

There are five distributing companies[3] for paranzella-caught fish in San Francisco, four of which are also producing companies as two of the companies combine their fleets in production and distribute separately.

These five companies represent an investment[4] in trawler boats of $436,500; in fishing gear for trawling operations (nets, ropes, etc.), of $68,900; in equipment, such as trucks, shore equipment, docks, markets where fish are prepared for the wholesale and retail trade, of $85,700. They have a monthly pay roll of $12,302.70 on boats; and on shore (employees, butchers, truckmen, net men, etc., who handle the drag net catches) of $13,200. The total number of employees is 178, not including executives and office help.

The direct expenses (cash outgo but not including depreciation or interest on invested capital) of these companies per year are: pay roll on boats, $147,632.40; pay roll of shore employees, $158,400; fuel oil, $27,000; fishing gear (nets, ropes, etc.), $35,000; maintenance on boats and equipment, $70,000, and $55,000 for insurance, taxes, licenses, supplies, hauling, etc. The total yearly cost is $493,032.40, which is a monthly average of $41,086.03.

[3] These are: Consolidated Fish Company, A. Paladini, Inc., Standard Fish Company, San Francisco International Fish Company, and Western California Fish Company. The last two named produce under the Associated Fisheries Company.

[4] Figures obtained from Mr. Bart A. Ghio, secretary of the Central Pacific Wholesale Fish Dealers' Association.

In addition these companies handle other fresh fish bought directly from fishermen. However, the foregoing figures relate only to paranzella-caught fish.

The trawlers of these companies produce for the market on the average about 1,000,000 pounds of fish each month. Some months

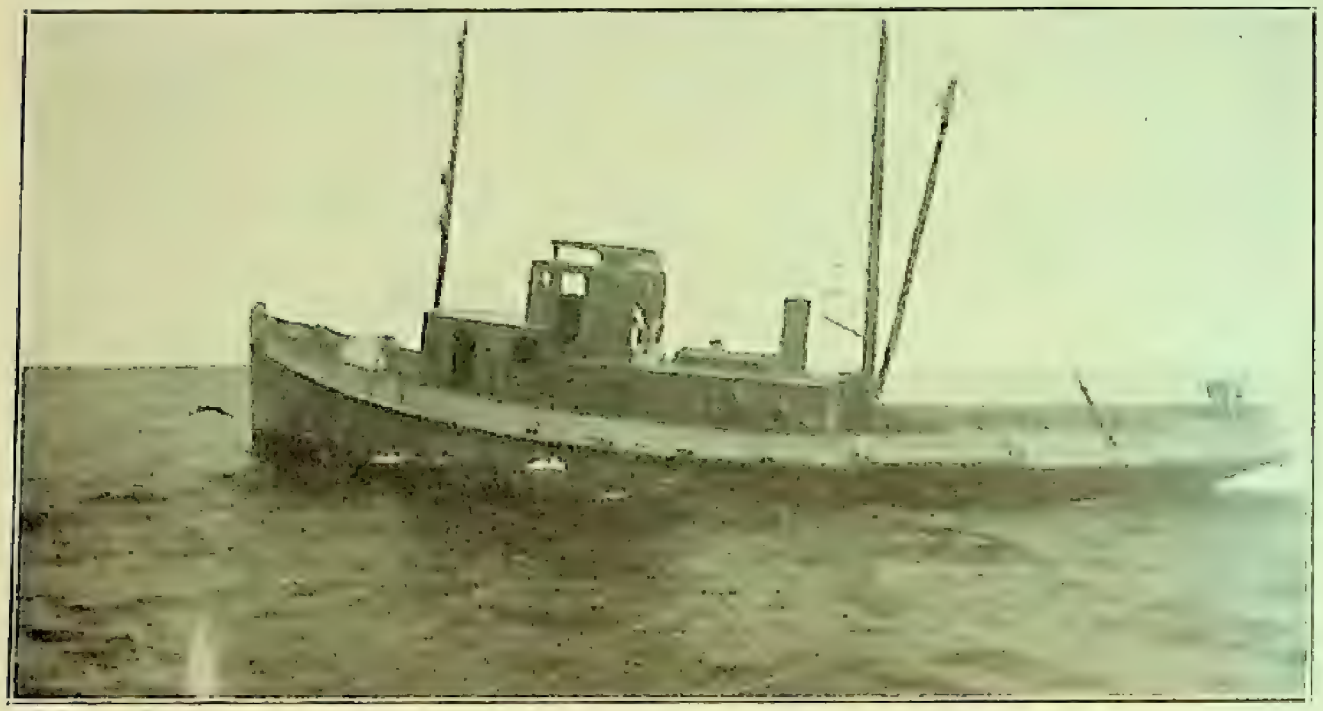


Fig. 9. A San Francisco trawler (helper boat) at sea. This represents one type of construction with a raised pilot house, galley forward. Notice the deck space aft, the trawl heads, boom, roller and the fair lead in the stern through which the line or warp is coming in. September, 1933.



Fig. 10. Another more common type of construction of the San Francisco trawler, with the pilot house forward, then galley and engine house. August 20, 1934.

it exceeds this figure; some months it is below the average. However, the yearly production runs between 12 and 13 million pounds. Of the total catch, 84 per cent is flatfishes and the other 16 per cent is made up of various species of bottom fish such as Pacific cultus, sablefish, rockfish, shark, skate, and miscellaneous fish. The sale value of the catch in the round averages about $55,000 a month or $660,000 a year. The

production by the paranzella nets is the fourth in poundage of the fisheries in the State, being exceeded by the sardine, tuna and mackerel.

GEAR

The boats used in trawling with the paranzella nets are all of the same type. They resemble very much the conventional tug boat, with the pilot house forward, a small galley and low engine house directly aft of the wheel house. Most of the deck space is aft, where the gear is handled and the catch is sorted. The crew's quarters are forward below decks with a hatch leading into the galley. In some of the large boats there is a bunk in the wheel house that the "skipper" uses. The galley is extremely small, considering the crew carried, for it acts as a shelter during bad weather besides being used for cooking. In most of the boats there is no place the men can sit down at table to eat but they must either stand in the galley, sit on their bunks or stay on the deck.

All boats now in the fishery are equipped with diesel engines, ranging from 60 horsepower on the smaller boats to 200 horsepower on the largest. All are rigged with power trawl heads, one large and one small, at the after end of the engine house on both port and starboard. There are also two masts, the after one being rigged with boom and tackle for lifting gear. This mast is also the towing bit where the end of the warp is attached by means of an iron collar. On the port side is a roller over which the net is landed, a removable sideboard fitting into place when the roller is not in use. On each side of the stern are special fair leads over which the warps are brought in. The after deck is left clear except for semipermanent bins close to the after end of the engine house and near the stern rail and a small hatch which opens to a very cramped hold with very little storage space. (See Figs. 9 and 10.)

The entire San Francisco fleet of trawlers uses manila for towing warps. In most cases this is 3¼-inch manila, although sometimes 2½-inch is used for part of the line, the 3¼-inch being nearest the net. As the net is towed between two boats, each boat carries one warp, which is coiled along the house on the starboard side when not in use. (See Fig. 11.)

The main boat of a set of trawlers, that is, the boat which carries the gear and lands the catch aboard, is manned by 7 or 8 men. There is a captain, usually an Anglo-Saxon, although sometimes Italian, whose duty it is to navigate the boat to and from the fishing grounds and to handle the boat while the gear is being lifted. Then there are an Italian boss fisherman, who tells the captain where he wants to go and directs all fishing operations; an engineer (either Anglo-Saxon or Italian); and the rest of the crew, usually all Italians. The latter are the fishermen who handle the gear and sort the fish. On the helper boat, which assists in towing the net, are a captain, engineer, and one fisherman. The latter handles the helper boat's warp.

The paranzella net is of Mediterranean origin but undoubtedly has been changed considerably from its original form. Even now there are variations in the nets among the several companies that operate them. Each net man has a few different ideas on how the net should be made. The nets vary in length from 75 to 110 feet from the

end of the wing to the end of the bag, according to the company using them. However, the basic parts of all the nets are similar. The nets are triangular sacks with very long wings and a relatively short throat leading back to a sack where the fish are retained. Figure 12 shows the various pieces that make up a typical paranzella net with over-all dimensions of 74 feet. It will be noticed at once that all pieces except the center wedge-shaped ones are square pieces of net, not tapered, which give the net when put together and hung an unusual fullness in wings and throat. The lead line (foot rope) and cork line (head rope) are attached directly to the two wedge-shaped pieces *E* and *F*, then in turn directly to the sack so that all of the strain is taken by the lines through the wedge-shaped pieces to the sack. The pieces from forward to aft are: *A* and *A'*, end pieces of wings (Italian "stazzi"). They are 25 meshes long by 75 meshes wide of 4-inch stretched mesh made of No. 12 twine. *B* and *B'*, back ends of wing ("lati"), are 100 meshes long by 150 meshes wide of 4-inch stretched mesh, No. 12 twine. *C* and *C'*, throat or belly ("manica"), are 200 meshes long by 300 meshes wide of 2½-inch stretched mesh, No. 9 twine. *E*, top wedge-shaped piece (top "seaglielto"), 108 meshes long, is 40 meshes at fore end tapered to 20 meshes (taper being taken up in the center), of 4½-inch mesh, No. 42 twine. *F*, bottom-wedged piece (bottom "seaglielto"), 47 meshes long, 30 mesh at fore end tapered to 20 meshes of 8-inch mesh, No. 120 twine. *D* and *D'*, which form the presack ("connalone"), are 50 meshes long, 110 wide of 2½-inch mesh, No. 42 twine. *G*, top part of sack ("sacco") is 60 meshes long by 90 meshes wide of 3½-inch, No. 72 twine. *H*, bottom of sack ("sacco"), 60 meshes long by 90 wide of 3½-inch mesh, No. 84 twine in fore part, No. 120 at extreme end. The lead line for the above net would be about 14 fathoms in length, the cork line about 12 fathoms.



Fig. 11. View of starboard side of trawler looking toward the stern as the warp is coming in and being coiled. The fore part of the net wing has just come up to the fair lead in the stern. September 27, 1933.

As stated before, the lead line is attached to the bottom "seaglielto," and the cork line to the top "seaglielto." However, the "seaglieltos"

do not follow the curve of the line, but the lashings increase as the curve becomes greater. (See Fig. 13.) Then the rest of the net is assembled, *A*, *B*, *C* and *D* being woven to each other, taking up meshes where necessary. For instance, in the attachment of *A* to *B*, two meshes of *B* are attached to one of *A*, etc. Each side of the net or webbing is then attached to the "seaglielto" and the lead and cork lines, so that the "seaglielto" are at the mouth of the net, one on top, one on the bottom. The attachments of the web to the "seaglielto" are with No. 60 or 74 twine by half meshes, the same size as the "seaglielto," and the web is hung on the lines by the fourth (every fourth mesh). The web is hung loosely on the lines, there being no take-up as is common in hanging beam or otter trawls, for the lines are equally as long as the hung webbing. The lead line of 3¾-inch manila is lightly leaded

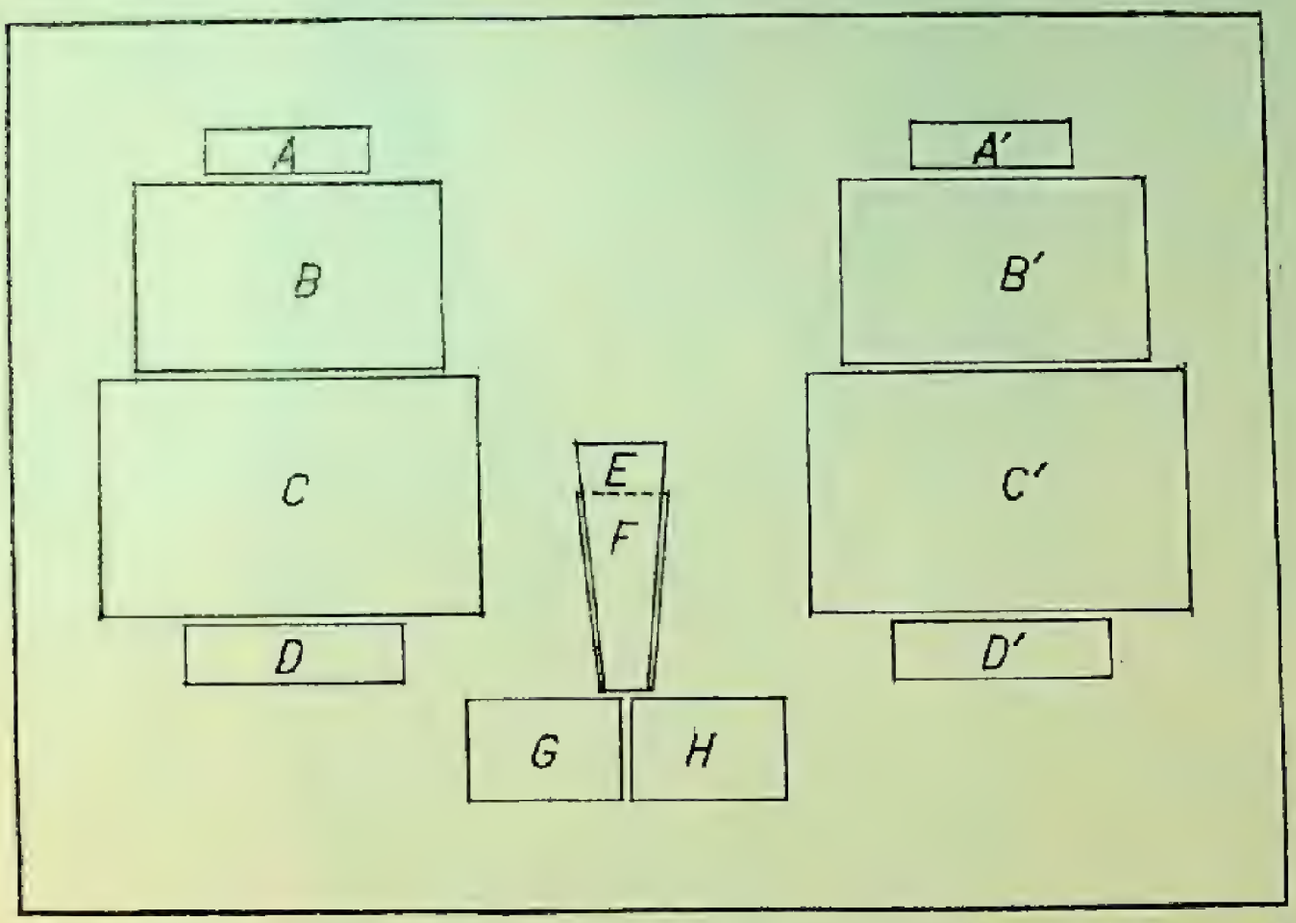


Fig. 12. The San Francisco paranzella trawl, showing the various pieces of net that make up the net. Explanation of lettered pieces in text. Drawn to scale.

with from 12 to 13 one-pound leads on each wing, and in addition there is usually a round wooden block about a foot long just forward of the quarters. The cork line of 1¼-inch manila contains fifteen 6- by 2-inch corks to each wing. At a point 4 feet forward of the wing is a 2-foot by 2-inch wooden bar. This bar is passed through the strands of the lead line. The lead line continues forward, makes a loop, and down to the opposite end of the bar, forming the loop to which the warp is attached. The cork line extends beyond the wing to be fastened on the bar. A small line is reaved through the meshes of the forward end of the wing and the ends of the line attached to the bar. (See Fig. 13.) The bottom "seaglielto" is woven on to the center of the bottom piece of sack, the top seaglielto to the top piece of the sack, and the sack put together and woven to the presack. The sack has two openings, one

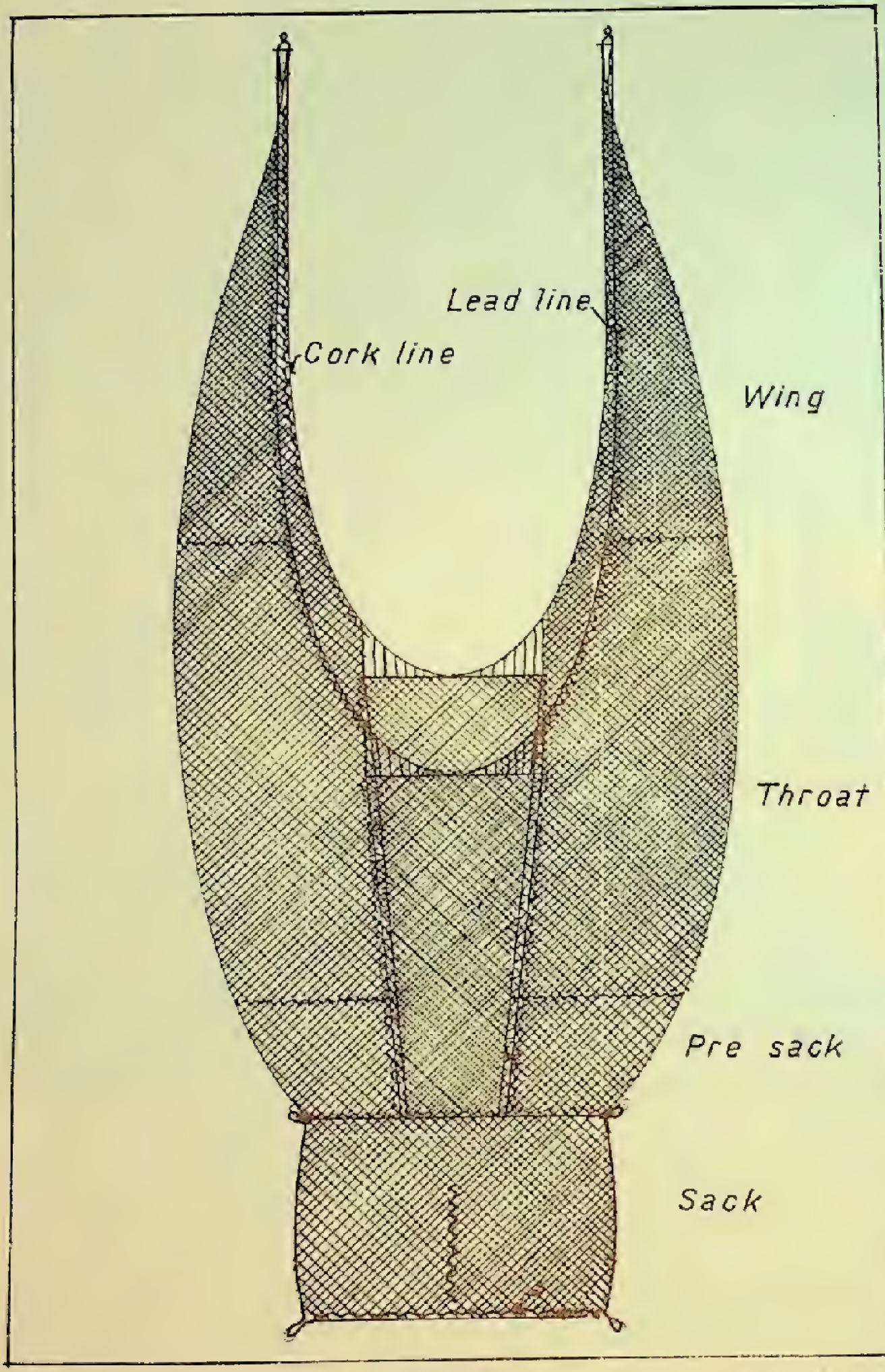


Fig. 13. Diagrammatic drawing (looking down from the top) of assembled paranzella net as laid out on land. The fullness of the wings and throat is shown. Drawn to scale.

near the extreme end, the other at right angles to the first in the center of the top piece. These are made by weaving small manila line into the mesh, forming a half-mesh on each side of the opening, and then passing the line back from each extreme of the opening through the manila half-meshes so that they meet at the center of the mouth to be tied. Passing around the outside of the sack is a 3¼-inch line lashed to the webbing, which at each corner is formed into an ear or loop. When in use the forward ears have a bridle attached to them that goes forward on a line to the starboard towing warp. This is known as the "cineco" and is used in lifting the gear. The after ears have short lines attached to them that carry forward and are bent on to the "cineco." These are also used to land the gear. The net is hung so that the lead line drags about a fathom behind the cork line.



Fig. 14. Hoisting aboard the wings of a paranzella net on a San Francisco trawler at sea. June 26, 1934.

OPERATION OF GEAR

The San Francisco paranzella trawlers operate at least six days a week, many seven days, but every member of the crews gets his day off each week. The boats leave their docks between 12 midnight and 2 a.m., depending on the grounds to be fished, and return with their catch the same day between 5 and 11 p.m. They fish in almost any kind of weather. There has to be a very severe storm to keep the boats in port. Plans are made so that the set arrives on the fishing grounds at daylight. The main boat takes a sounding to check the depth of water; then the crew of the main boat pays out the net over the stern until the end of the wings is reached; next the partner boat comes alongside and heaves a line aboard the main boat. This line is attached to the warp of the partner boat; the partner boat's warp (always the port warp) is heaved in and bent on to the port lead (the 25-foot leads are attached to the loops at the end of the wings and consist of three 3¼-inch lines lashed together). The starboard warp and the "cineco" (line to sack ears) having been already attached, the partner boat pulls away from the main boat

and both boats go forward at full speed, allowing the warps to pay out over the side from the coils until almost all the line is out. Then the boats idle and lose headway while the ends of the warps are reached. Attached to the end of the warps are pieces of chain which reach from the after mast (the towing bit) over the stern. The net is allowed to settle a few minutes and then at a whistle signal from the main boat, towing commences. The net is towed at a speed between two and three knots per hour for one and one-half to two hours. The helper boat keeps on the same course and is separated from the main boat by 1000 to 1500 feet.



Fig. 15. Hoisting on board a small sack of paranzella-caught fish. June 26, 1934.

Each boat of a set uses from 800 to 1000 fathoms of tow line. This is all payed out in any depth from 50 to 100 fathoms of water so that the ratio of line out to depth is at least 8–10 to 1 and often much greater.

At the end of the dragging time, the main boat signals the partner vessel to be ready. Then at another signal both boats go into reverse and at the same time bring in the warps. On the main boat, one man hauls in the line over the cathead while another coils it; and on the helper boat, one man does both jobs. As soon as the hauling is well started, the boats are allowed to drift, the hauling of the lines gradually pulling the boats to a position over the net. For about 20 minutes both boats haul in the lines. Then at a signal the partner boat comes alongside and passes its line to the main boat. From then on both lines are pulled in on the main boat, the helper's line being passed over the side and the slack taken up by the helper as it stands by. Shortly after the helper's warp is passed to the main boat, the "ciucco" line comes over the fair lead. When this appears, the hauling is stopped and the "ciucco" line is unbent and passed to the port side over the roller through a block near the starboard rail and over the smaller cathead on that side. Then hauling commences again, the "ciucco" line being hauled at the same time so that the weight of fish in the sack is taken off the rest of the net. Soon the leads appear, then the beginning of the wings. Next the leads are taken out of the

fair leads, passed to the port, a sling put around the ends of the wing, the boom tackle hooked in, and 20 to 25 feet of net is hoisted on board. (See Fig. 15.) While this is going on, the "ciucco" line has been brought in so that the top of the sack is at the surface of the water on the port side near the roller. Successive pieces of the net are brought aboard with boom tackle until all the net is in except the sack. The procedure from the beginning of the haul until the sack is alongside takes about 30 minutes. From then on the time required to get the catch aboard depends on the size of the catch. If the catch is large, some of it has to be dipped out. To do this, the "ciucco" bridle is untied and the lines made fast to davits on each side of the roller; the lines attached to the after sack ears are also snubbed down. Then the mouth in the top piece of the sack is unlaced, so that with long-handled dip nets the fish can be dipped out and dumped on the deck. When enough fish have been taken out in this manner the mouth is tied up again, the boom tackle hooked on, the lines released and the sack hoisted on board over the roller. (See Fig. 15.) Then the bottom mouth is unlaced and the fish allowed to spill out on deck. (See Fig. 16.)



Fig. 16. A deck-load of fish just untied from the sack. Notice the octopus held by the fisherman. September 27, 1933.

The boats then get ready for another drag[5] either on the same grounds or other ones. Using another net they shoot the gear again. Some of the crew clean the fish out of the used net, lace up the mouth and arrange it so it can be used for the following drag. While the next drag is being made the fish are sorted.

The boss fisherman and the fishermen sort out the marketable fish from the catch as the fish slosh back and forth across the deck with the roll of the vessel. A man scoops up a shovelful of fish, rests it on the rail, picks out the large and marketable fish by hand, and tosses them into their respective bins. The rest of the shovelful, consisting of trash and small fish of all kinds, is dumped overboard. (More will be said of the catch later.) When all the catch is sorted,

[5] As a rule at least three drags a day are made by each set. However, as fish have become less abundant, four drags a day are often made, and sometimes five.

the decks are washed down and the crew is ready to haul the next net when the time arrives.

The paranzella net, because of its construction whereby the strain is taken by the cork and lead lines, then by the "seaglieltos" directly to the sack, allows the webbing of the wings and throat to be bowed out by the force of the water while being towed, and allows the meshes to stay open much more than if the strain of the sack were on the webbing. In addition, the force of water against the full wings aids in spreading the opening of the net. This two-boat gear should fish with a horizontal spread of from 50 to 70 feet, depending on the size of the net, and perhaps a vertical opening of three or four feet. The vertical opening could perhaps be enlarged by the use of glass floats instead of the corks, because the cork becomes decreasingly effective as greater depths are fished.

CATCH

The catch of the net at sea (only fish that live on or near the bottom are taken in these nets) is very different in aspect from that landed at the dock for market use, for at the dock, landings represent the sortings of good marketable fish from the several drags. Of course, individual catches from the grounds vary considerably in the varieties taken, but a combination of the fleet's catches from all grounds over a period of six months, January to June, 1934, by species reveals the following percentages of fish landed at the dock:

Species	*Per cent*
Shark (*Squalus suckleyi* and *Rhinotriacis henlei*)	1
Skate (*Raja binoculata* and *Raja inornata*)	2
Sablefish (*Anoplopoma fimbria*)	2
Pacific cultus (*Ophiodon elongatus*)	2
Tomcod (*Microgadus proximus*)	*
Small pointed-nosed sole (*Parophrys vetulus*)	9
Large pointed-nosed sole (*Parophrys vetulus*)	37
Rex sole (*Errex zachirus*)	5
Round-nosed sole (*Eopsetta jordani*)	20
Northern halibut (*Hippoglossus hippoglossus*)	1
California halibut (*Paralichthys californicus*)	*
Sand dab (*Orthopsetta sordida*)	7
Starry flounder (*Platichthys stellatus*)	4
Turbot (*Pleuronichthys;* 3 or 4 species)	1
Rockfish (*Sebastodes;* several species)	5
Kingfish (*Genyonemus lineatus*)	*
Hake (*Merluccius productus*)	*
Market crab (*Cancer magister*)	*
Cabezone (*Scorpaenichthys marmoratus*)	*
Octopus (*Polypus hongkongensis*)	*
Miscellaneous fish (consisting of odds and ends of the foregoing species)	2

* Less than one-half of one per cent.

In addition to the above mentioned species, there are also mixed in the catch from time to time, under the large pointed-nosed sole classification, various species of flatfish such as slender sole (*Lyopsetta exilis*), fringe sole (*Psettichthys melanostictus*), scaly-fin sole (*Isopsetta isolepis*), and broad-fin sole (*Lepidopsetta bilineata*). These last four species play a very minor role in the catch, coming in only occasionally during certain seasons and from certain grounds. The fishery depends

on two species of flatfish for poundage; the pointed-nosed sole (large and small) and the round-nosed sole make up 66 per cent of the catch, with the sand dab next in importance making up 7 per cent of the catch, then rex sole 5 per cent, rockfish 5 per cent, and flounder 4 per cent. Individually, the remaining species are insignificant. Also 84 per cent of the total landed catch is flatfish, the other 16 per cent being divided among rockfish, Pacific cultus, skate, sablefish, shark, etc.

The fish of the paranzella boats are caught and landed the same day (none is cleaned and rarely are they iced on board) and are taken to the wholesale markets where they are cleaned, filleted and prepared the next day for the trade, so that most of the fish are in the consumers' hands at least twenty-four hours after being taken from the water.

The catch at sea represents a hodge-podge of varieties of fish and sizes never seen in the markets. Sizes range from tiny 2-inch fish to 6- and 7-foot sharks and skates with a wing spread of several feet. A great deal of the fish caught in the net is what is known as trash. This trash is dumped overboard, usually dead except for the crabs. Trash fish consists of sharks, skates (except a few that are saved for the market), very small rockfish, small sablefish, large and small slippery sole (*Microstomus pacificus*), arrow-toothed sole (*Atheresthes stomias*), hake, all small soles of all species less than 9 inches in total length (except the sand dabs and rex sole which are sometimes saved at a size of 6 inches), and of course all the odds and ends of sea life—shells, nonmarketable crabs, starfish, etc. A large percentage of the trash fish by weight is the sharks and skates, though on rare occasions small sablefish make up a large part of the trash. The arrow-toothed sole and slippery sole are soft, slimy fish that have no sale; so very few are ever saved for market. The sablefish (blue cod) under 5 pounds have only a limited market. However, the larger fish of this kind are readily sold for salting and smoking. Hake is also a soft inferior fish, so is not sold to any extent. Pointed-nosed soles, 9 inches in total length, are saved. Those averaging 10 to 11 inches are classed as small soles by the trade. However, in times of great abundance of large soles, only a limited number of small soles is landed, the rest being returned to sea. Large pointed-nosed soles are those above one-half pound in weight. This fish may reach 2 to 3 pounds, but the majority are about 1 to 1½ pounds. Round-nosed sole ("petralie") are the choice of the catch, usually ranging in size from ½ to 5 pounds, averaging 2 to 3 pounds. As a rule very few small (less than 9 inches) round-nosed sole are taken in the catches. As a consequence, few are wasted. Sand dabs are utilized from 6 inches upward in size, even smaller ones being used when the larger sizes are scarce. Rex sole, a slender fish, used for the market, ranges in size from 7 inches upward to 12 inches. Flounders as a rule are not taken below 10 inches in length and are all landed. Almost all the rockfish and Pacific cultus are saved except the very smallest, those below 6 inches in length. Halibut, both kinds, are all saved as no small individuals of these species are taken in the waters fished by the nets. Turbot from 8 inches in length upward are all utilized, the rest being returned to sea.

The percentages of the various species of fish taken by the nets vary according to the grounds fished and the seasons. A drag may be made yielding 90 per cent sharks and skates, whereas another may

produce almost all flatfishes with a scattering of other species. It is impossible at this time to give any definite information as to the percentages of species caught on definite grounds or for the fishing area as a whole. However, in regard to waste of marketable fish, there is no question that the greatest waste is of small, immature pointed-nosed sole, for this species is by far the most abundant of any species taken by the nets on most of the grounds. This condition, in the interests of conservation and for the benefit of the men in the industry who depend on this fishery for their living, should be corrected and is being corrected by the use of larger mesh which allows the small fish to escape through the meshes while the net is dragging. More will be said of this later.

The catching of the market crab by these nets has been a source of bitter controversy. However, from observations made on the paranzella boats, the crabs when brought up in the nets have always beeen in good condition, alive and without legs missing. During the open season the male crabs of sufficient size are saved for the market. The females and small crabs are tossed back into the sea, and there is no doubt that they live to be caught again. Occasionally, crabs may be broken by the drag net and killed, but the amount is probably very small.

Another claim against this gear in California, as elsewhere, that has come up time after time [6] is that the nets destroy the bottoms as feeding grounds, denude them of all animal life and destroy the spawn of all fishes. These claims are not in any case supported by facts. Small organisms such as worms and clams, larval fish, small crustaceans, etc., will very easily slip uninjured through the mesh of these nets, as will eggs from any of the fishes that have demersal eggs (eggs that rest on or near the bottom). The flatfishes have pelagic eggs (suspended near the water surface). In 1914, the United States Bureau of Fisheries [7] investigated just such a claim against the otter trawl fishery on the Atlantic coast. They came to the conclusion that the drag nets did not denude the bottom of animal life, but on the contrary acted as a cultivator, stirring up the mud and exposing the small organisms so that better feeding grounds resulted.

There is no question that the paranzella nets have been wasteful of small fish and at times of large fish, even more so in the past when 1½-inch mesh was used in the sacks (Scofield, op. cit.), than in more recent years, but as to being destructive of bottoms, there is no evidence at the present time.

FISHING GROUNDS

In the early years of paranzella trawling, the operations were all within San Francisco Bay, then gradually the fishing spread outside. In 1906, the California State Legislature prohibited the use of the nets in the Bay because of the decreasing supply of fish. From then on all fishing was done in the ocean. However, for many years there were only two main fishing grounds: one four to eight miles southwest of Point Reyes, the other south of the San Francisco lightship. Gradually, the extent of the grounds increased in area and in depth of water until

[6] Scofield, N. B. Paranzella, or trawl net fishing in California. Pacific Fish. Soc., Trans., 2d meet., 1915, pp. 45–51, 1916.

[7] Alexander, A. B.; Moore, H. F.; and Kendall, W. C. Otter-trawl fishery. U. S. Bur. Fish., doc. 816, app. 6 to Report, 97 pp., Illus., 1915.

now the waters from Monterey to the California-Oregon line out to 100 fathoms are fairly well fished. The present restrictions (as shown in the fish and game laws) on trawl fishing in waters covered by the San Francisco fleet are: It is unlawful to fish within three miles from shore from Pigeon Point, north of Monterey Bay, to the Oregon-California line, and it is unlawful to fish in water less than 25 fathoms in depth from Pigeon Point south to the Carmel River, below Monterey Bay.

In the last few years, beginning in 1929, the fishery has spread northward from Point Arena to virgin trawl grounds so that now (1934) from April until October or November, the bulk of the fleet fishes out of Eureka, sending the catch, in the round and iced, to San Francisco daily by land. During the stormy winter months, the fleet returns to San Francisco to operate on the old grounds. Certain fishing grounds are much more productive than others, and the seasons of the year seem also to play a part. The grounds off Eureka and northward have been heavy producers in the last few years. However, the banks off San Francisco around Point Reyes, Farallon Islands, off the lightship, off Point Montara, off Halfmoon Bay, still yield large poundages as at times do the grounds off Santa Cruz on the south and Fort Bragg on the north. At present, most of the fishing is done in water 50 to 100 fathoms in depth, because the fishermen have learned that they get a larger quantity of round-nosed sole (the choicest fish) in the deeper waters.

MARKETS

Each company in San Francisco that operates trawlers handles and markets its catch to both wholesalers and retailers. Every morning between 4 and 5 a.m., the marketmen begin to clean and fillet the previous day's catch, and by 7 a.m. deliveries to customers are being made. A large bulk of the sole and flounder catch is filleted. Some, however, is sold in the round or cleaned heads on. Sand dabs and rex sole are cleaned but not filleted. Rockfish are usually cleaned and are occasionally filleted. Pacific cultus, sablefish, turbot, and halibut are sold cleaned. In case of an over-supply, the fish are cleaned and put in ice-boxes for use the next day.

All the fish is sold fresh, the dealers distributing a large portion of their catch in San Francisco and cities and towns in the Bay area. A considerable amount of fillet in special tins or boxes, as well as cleaned fish, is shipped to Los Angeles, Salt Lake City, and to inland cities in California. At times shipments are made to Denver and St. Louis.

RESEARCH ON THE FISHERY—RECENT DEVELOPMENTS

A little over a year ago, the Bureau of Commercial Fisheries of the Division of Fish and Game, instigated a plan of research for the paranzella fishery. This plan was started in order to learn more about this important fishery, which from preliminary catch studies, appeared to be decreasing the available supply of bottom fishes.

Of primary importance to the Division as well as to the producers is the state of the supply of fish, what the cause of the decrease in abundance is, and what is the remedy.

Of secondary importance is information about the various fishes that make up the catch. What are the important species in terms of poundage? How long or to what age do they influence the fishery? At what size and age do they mature? How fast do they grow? What are their movements or migrations? Where are the young reared? What is the relative relationship of small young fish to older larger fish in point of numbers?

Studies of the average catch per net per day, a measure of the availability of flatfish to the fishermen, show a 32 per cent decrease in the catch of all flatfish from 1924 to 1933. This is not as bad as it might be, for what is thought to be one of the main contributing causes of this decrease is the waste of small unmarketable flatfish that has been going on since the fishery started 58 years ago. If the populations of flatfishes had not been extremely numerous and very prolific, the fishery would have long since become unprofitable. The waste has not been wanton, for at the beginning of the fishery, because fish were so abundant, it made little difference what was wasted, and as time went on, it became a habit that was not even considered.

To eliminate the waste of small fish, the producers,[5] following suggestions made by the Bureau of Commercial Fisheries, voluntarily began to enlarge the mesh in the sacks of their nets from 3½-inch stretched mesh to 5- and 6-inch mesh in order to allow the small fish to escape unharmed. At the present time, October, 1934, all producers in San Francisco are using sacks of large mesh at least part of the time, and alternating with the smaller meshed nets on hand that have to be worn out. Two producers are also enlarging the mesh in the fore part of the trawls to a uniform 4-inch stretched mesh. There are several advantages to the larger mesh:

1. It allows the small fish to escape and grow to a marketable size; in the meantime perhaps spawning at least once before being caught for market.

2. The expense of making and mending the net is less than with the smaller mesh.

3. The large mesh allows a great deal of the mud to pass out of the net, particularly the sack. It enables the net to be towed at faster speed because of less resistance, thus covering more ground in the same length of time, and it reduces the work of sorting at sea. It is felt that within three or four years, there will be noticed an increase in abundance of larger fish and that, with the continual use of large mesh, there will always be a sufficient surplus to insure a constant supply of bottom fish. Only time will tell, but constant observation of the catch, as well as continued studies of catch records, will be necessary to detect the changes.

A system of daily log records combined with fishing area charts was inaugurated on January 1, 1934. These perfect the statistical record of the paranzella catch and give the number of drags, location of fishing grounds, depth of water, proportion of species taken each drag, and pounds caught. The first six months of records are in and have

[5] The writer is indebted to the paranzella companies, their boat crews, and all employees of these companies, as well as to the secretary of the Central Pacific Wholesale Fish Dealers' Association for full cooperation and aid in all work that has been attempted.

been compiled, and much of the information they contain has been used in this paper.

During the past year, as time permitted, observations, measurements, and scale and otolith collections have been made from the more important species of flatfish. This will be continued and other projects started, so that the major facts of the life history of these species may be determined. Through these researches and through close contact with the fishery, knowledge beneficial to both the industry and the Division will be obtained.

THE CRAB FISHERY OF CALIFORNIA*

By J. B. PHILLIPS

(Photographs by the author)

INTRODUCTION

The only species of crab that is protected in California is the market crab (*Cancer magister*), sometimes called white crab or Dungeness crab. The market crab forms at least 99½ per cent of the entire commercial crab catch of California. Aside from this crab, less than one-half of 1 per cent of the annual crab catch is accounted for in the Los Angeles area by three species of rock crabs (*Cancer productus, C. antennarius,* and *C. anthonyi*).

The market crab is one of the more important fresh fishery products (marine) that the markets of California handle. The total annual poundage of crabs sold, which is usually one to three million pounds, is outranked by several of the well-known food fishes, but since 1918 has occupied fifth to seventh place among the California fishery products.

In California, market crabs are reserved for the fresh fish trade under California Division of Fish and Game regulations which prohibit canning, pickling or other forms of preservation. Further protection against depletion is provided by regulations that prohibit the possession of female crabs and the taking of male crabs that are less than seven inches, measured from point to point across the curve of the back.** It is also illegal to take market crabs for a period of about three and one-half months during time of molting.

DESCRIPTION OF MARKET CRAB

The market crab is the largest of the crabs along our coast, sometimes reaching a breadth of nine and one-half inches across the back. It belongs to the family Cancridae, in which are classed several smaller species on our coast. There are several other families of crabs along the California coast but none is used as food to any extent. In all, there are some 75 species of crabs inhabiting California waters, most of these being found among rocks.

The several species of crabs along our coast belonging to the genus *Cancer* have saw-like teeth on the front and sides of a somewhat oval-shaped shell. One identification mark in the market crab is that the top side of each larger pincer has a conspicuous row of spine-like projections. Also in the market crab, the ends of the pincers are whitish or light colored as compared to the blackish ends of the pincers of three other crabs (*C. productus, C. antennarius,* and *C. anthonyi*) with which it might be confused. The only other crab with which the market crab might be confused is the slender crab (*C. gracilis*) which, however,

* Contribution No. 142 from the California State Fisheries Laboratory. October, 1934.

** The size limit was raised from 6 to 7 inches in 1911.

seldom exceeds three and one-half inches in breadth. The slender crab also has light tipped pincers but it can be distinguished by the joints of the last walking legs which are long, slender and hairless.

The abdomen of the female market crab is much broader than that of the male. (See Fig. 17.) The abdomen is the flap-like process folded up against the posterior under side of the body. This flap-like abdomen of the crab is not only broader in the female but has six movable joints beyond the carapace. The male abdomen has but four joints beyond the carapace. Female market crabs average smaller in size than the male crabs.

The color of the fresh market crab is somewhat reddish or purplish brown on the upper surface and yellowish and whitish on the lower

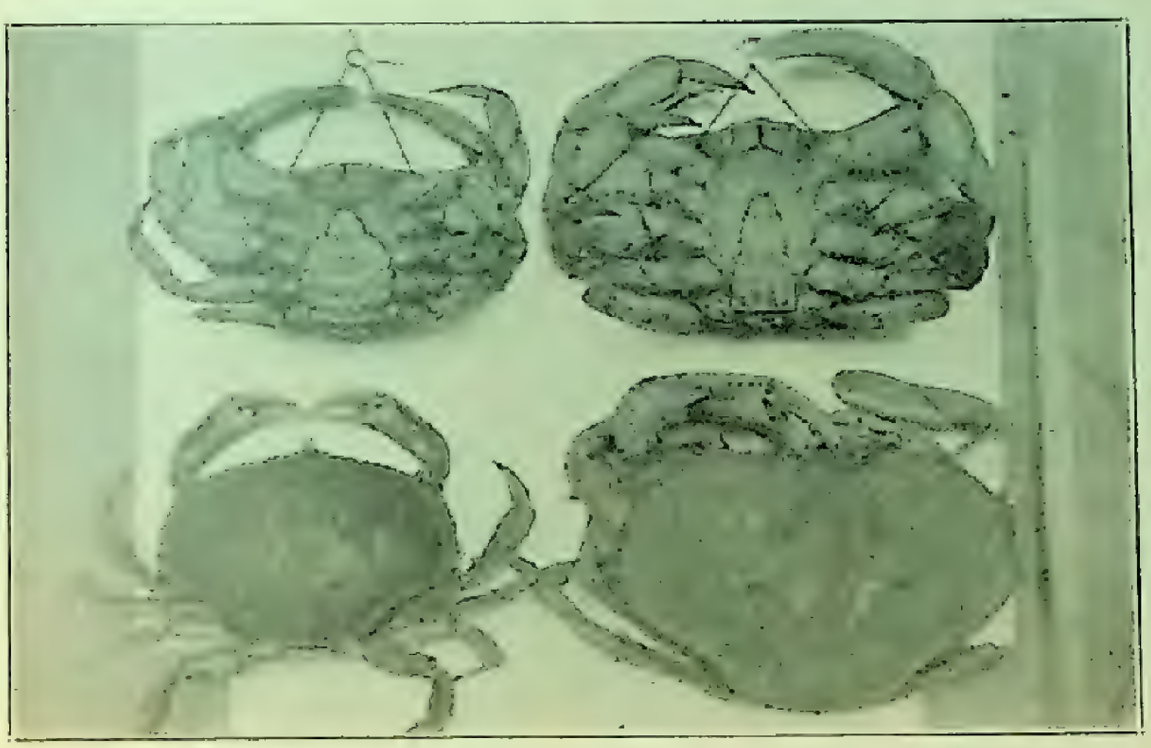


Fig. 17. Market crabs (*Cancer magister*). The top two crabs show the ventral or under side of a female (left) and of a male (right). Note that the female abdomen is broad and that the last segment is much smaller than the others. Note that the male abdomen is narrow and has fewer segments.

The lower two crabs show dorsal or back views. The crab on the right appears lighter as it is a dried specimen. Note characteristic whitish markings. June, 1934.

surface. Upon being boiled, the crab takes on the bright red color commonly seen in the markets.

The market crab ranges from Unalaska to Magdalena Bay in Lower California but is not taken in marketable quantities south of Monterey Bay. To the northward of California, it is called the Dungeness crab. It is taken over a sandy bottom for the most part but can be taken over a clay or muddy bottom at times. Off the California coast, this crab is found from low tide mark to a depth of at least 90 fathoms.* The commercial fishery, however, rarely operates in more

* G. H. Clark, of the California State Fisheries Laboratory, who accompanied a commercial drag boat on a trip off Half Moon Bay on March 24, 1933, reported the taking of nine legal-sized market crabs during one drag in 93 fathoms of water, with as many undersized crabs that were returned to the water. He also reported several large crabs taken in a drag off Pt. Reyes in 90 fathoms. On other occasions, larger numbers were taken in somewhat shallower water.

than 35 fathoms of water, the main fishery being carried on in 5 to 20 fathoms.

MOLTING OF CRABS

Molting is general among crustaceans. The hard shell of the crab prevents growth and so at intervals of about one year the entire hard shell of the crab is cast off or molted. Before the actual molt, a new protective covering is started, but this is uncalcified and therefore soft. Preparatory to and during molting, the crabs bury themselves in sand in shallow water as a protection. During the period when the old shell is cast off, the crab is known as a "soft" crab and it is during this interval of a few days that the crab undergoes a period of rapid growth before the new shell becomes calcified and fixes the size of the crab until the next molt. During the "soft shell" stage, the flesh is watery and unfit for food. At molting time the old shell slits at the junction of the carapace and abdomen and the crab, now in the soft shell stage, backs out of the old shell through this slit. It is during the molting period that missing legs are rejuvenated. Following the first molt, after such a mishap, a replaced leg is considerably smaller than the original, but with succeeding molts it attains its normal size.

At times, the empty shells are washed up on some beach in great numbers and to the uninformed it might appear that in some manner there had been a wholesale destruction of crabs. Obviously such is not the case. However, there have been instances where whole soft shell crabs were found dead upon the beach along with cast shells. Investigation has shown that usually such an instance was preceded by an extreme low tide when a heavy ground swell was running, causing rollers to break far from shore. The helpless crabs may be dislodged and killed by such a pounding and eventually washed onto the beach. There have been a few cases reported where a clam digger, working an extremely low tide on an open ocean beach, dislodged soft shell crabs from the sand.

RELATIVE IMPORTANCE OF VARIOUS AREAS

Although the market crab has been reported as far south as Magdalena Bay, only occasional specimens are found south of Pt. Conception. From Pt. Conception northward to Monterey Bay, the market crab is not abundant enough to warrant catching commercially. The commercial fishing for the market crab commences at Monterey Bay and extends northward along the Pacific coast into Alaska.

Along the California coast practically the entire crab catch during recent years has been made within the following areas: San Francisco (Pt. Reyes to Halfmoon Bay), Eureka (Mad River to Eel River, occasionally to Crescent City), and Monterey Bay.

The largest catches by far are made in the San Francisco area, from whence came 75 to 95 per cent of the annual State poundage during the period 1918–1933. The average for this period is 90 per cent. All but 1 per cent of this catch is landed at the port of San Francisco. Small quantities are landed at Oakland and Sausalito.

Outside of the San Francisco area, the next largest catches are made in the Eureka area and landed in Eureka and Fields Landing.

During the period 1918–1933, from 2½ to 23½ of the annual State poundage was taken from this area. The average for this period is 6 per cent. A small amount is landed occasionally at Crescent City.

The only other area of consequence is the Monterey Bay area, from which was taken 0.1 to 13 per cent of the annual State poundage during the period 1918–1933. The average for this period is 3¾ per cent. The bulk of this catch is landed at the port of Santa Cruz, with Monterey receiving usually one-fifth to one-tenth of the yearly take. A small amount of crabs is landed at Capitola, about four miles west of Santa Cruz on Monterey Bay. Most of this is delivered to Santa Cruz, a small portion being sold locally. Since 1933, a few skiff fishermen, working out of Moss Landing in the spring and summer



Fig. 18. A portion of the crab boat fleet at San Francisco. These are the types of boats that fish for crabs in the San Francisco and Monterey areas. A small percentage of the boats differ from this Monterey type, which is characterized by the clipper bow and wide flaring gunwales. The boats used for crabs in the Eureka area are of approximately the same size but the lines of the boats differ. May, 1934.

months, have caught and sold quantities of crabs to dealers in Santa Cruz and Monterey.

Bodega Bay has accounted for an average of less than one-half of one per cent of the State total during the 1918–1933 period.

The San Francisco fleet sometimes fishes as far south as Halfmoon Bay, and in addition there are several boats that work regularly out of Halfmoon Bay and land their catch at that port. These boats fish southward to Pescadero.

Although the bulk of the crabs caught commercially during recent years has been taken in the areas outlined above, crabs have at different times in the past been taken between the Oregon State line and Monterey Bay at various places outside of the designated areas. Drag boats have also taken crabs off shore in various depths.

AVERAGE SIZE OF MARKET CRABS TAKEN IN DIFFERENT AREAS

For computing catch statistics, the Bureau of Commercial Fisheries has for many years been using an average of 24 pounds per dozen for all market crabs delivered to California markets. As the markets buy and sell crabs by numbers instead of weight, an accurate record can not be gathered. There is a variation in the sizes and weights of market crabs taken in the different areas during some seasons, especially in Monterey Bay, but over a period of years it seems that the 24 pound per dozen average has been accurate enough for all practical purposes. At the 24 pound per dozen average, male crabs will average about $7\frac{7}{8}$ inches across the back.

Louis Beverino, veteran marketman of Santa Cruz, states that during some seasons it is not unusual for Monterey Bay crabs to fall noticeably below the average in size, weight and condition. Monterey Bay is the southern limit of commercial crab fishing and it may be that during some seasons environmental conditions are unfavorable and crabs do not attain their usual standard of weight and condition.

SAN FRANCISCO AREA

FISHING LOCALITY

For many years crab fishing in the San Francisco area has been carried on off the open coast between Pt. Reyes to the northward and Halfmoon Bay to the southward, a distance of about 50 miles. Crab catching is carried on in 4 to 24 fathoms, with most of the fishing between 5 and 10 fathoms. The locality fished most extensively is between Bolinas Bay and a short distance south of San Francisco. A very small amount of fishing is done off the south shore of the Golden Gate between Fort Point and the ocean. However, in the earlier years of the fishery and up until about 30 years ago, the catching of crabs was confined entirely to this stretch off the south shore of the Golden Gate and off the San Francisco side of San Francisco Bay.

GEAR

Crab hoop nets have always been used by San Francisco fishermen. These hoop nets are uniform in construction, being obtained from supply houses either made up or in parts. A complete crab hoop net consists of a large iron hoop and a smaller iron hoop separated by webbing, a wire bait container, a section of burlap to fit into the bait container, 10 to 30 fathoms of heavy twine attached to the large hoop by a 3-point suspension, and a small float.

The large hoop, which is about 33 inches inside diameter, is made of $\frac{3}{8}$- or $\frac{1}{2}$-inch round iron bar. The smaller hoop, which outlines the floor of the net, is about 15 inches inside diameter and is made of $\frac{3}{8}$-inch iron bar. Three $\frac{3}{8}$-inch bars radially reinforce the small hoop. As the spaces between the bars would allow large crabs to fall through when the net is raised, a few turns of heavy twine between bars forms smaller spaces. (See Fig. 20.) (Cost of hoops, San Francisco, May, 1934, $1.25.)

A cup-like bait container of 12- to 14-gauge wire mesh is attached in the center of the small hoop on top of the cross bars. One side

of the bait container is hinged to one of the bars by a few turns of heavy twine. A piece of gunny sack fits into the cup. The piece of sack is used to force the bait securely against and partly through the meshes of the bait container. (Cost of bait container, San Francisco, May, 1934, 35 cents.)

Three bridles are fastened to the larger hoop to form a 3-point suspension. These bridles are of 90- to 168-thread, hard-laid twine and are as long as the diameter of the larger hoop. They terminate in a single main line, the length of which depends upon the depth fished. The main line is as long as the deepest fishing encountered and is adjusted to shallower depths by tying up a certain number of coils. The main line is hard-laid twine of 90- to 168-thread.

The floats are made from red cedar. Redwood has been tried but its sustained floating qualities have been found inferior to that of red cedar. Cork and copper floats were also tried in the past. The floats are cylindrical, one end being flattened and the other end rounded abruptly to a point. In appearance a float looks like a short heavy projectile. The outside length is about 11½ inches and the outside diameter about 5½ inches. The float is hollowed from the flat end and a cedar cap fits over this end. The float is soaked with linseed oil to prolong its water-resisting properties. At the pointed end of the float, a ¾-inch metal eye is screwed. The retrieving line is tied through this eye. When floats are purchased by crab fishermen, the seam where the cap fits over the end of the float is taped, and the float painted according to the owner's desire. As each fisherman has many traps, a number is usually painted on the flat end. (Cost of float, San Francisco, May, 1934, 65 cents.)

BOATS

In the earlier years of crab fishing, sail boats were used entirely, but during at least the past 30 years, power boats have been used exclusively.

Since 1918, between 200 and 250 boats have regularly fished crabs each year in the San Francisco area which includes Sausalito.

The crab boat is not a specially built boat but is an ordinary jig boat that can also be used for other types of market fishing. With certain minor additions of labor-saving devices, it is used for fishing crabs. The most popular type of boat is the "Monterey style," distinguished by its clipper bow with a wide flare forward and a compromised stern. These boats vary in length between 20 and 35 feet, and the average beam is about 8 feet. The boats are powered by 1- or 2-cylinder gasoline engines that range from 6 to 12 horsepower. There is a small pit near the tiller and a little astern of amidships a tiny house is built up over the engine control pit. This house is open at the rear and serves as protection from spray and wind. All the crabbing operations are performed from this engine pit when hoop nets are used.

To speed up and facilitate crab fishing on a commercial scale, a small drum (gurdy) of 4 to 5 inches in diameter has been added. This small drum is placed about a foot above deck on the starboard side of the boat and is operated by a chain drive take-off from just behind the flywheel. It is engaged when needed by a foot clutch. In addi-

tion to the small drum, a small deep-grooved iron block on an iron bar davit arm completes the crab hoop net raising equipment. This davit arm and block is demountable so that it can be stowed away. When in position, the block is about 4 feet above deck and swings over the side of the boat opposite the small drum. This additional equipment costs about $50 installed. This net raising equipment has been in use since the early years of power boat operations in the fishery.



FIG. 19. Hoop-net raising equipment on jig boats operated for crabs in the San Francisco and Eureka areas. *A*, demountable iron davit arm and block. *B*, power-driven drum. May, 1934.

OPERATION OF HOOP NETS

In the San Francisco area, a string of traps consists of 20 to 30 hoop nets, operated by one man with his boat. The nets are stacked in two piles on deck within easy reach aft the engine pit.

The crab fishermen leave port early enough to reach the chosen fishing grounds by daybreak. In the spring and summer, this means leaving port as early as 2 a.m. When the grounds are reached, the nets are set out one at a time in a line paralleling the shore. Best fishing is encountered when the tide starts to recede and the bait juices are more widely dispersed. Each hoop net is baited and dropped into the water while the boat is traveling at about half speed. The nets are spaced so that when picked up, enough time is allowed to remove contents, rebait and drop net into water again before the next hoop net is reached. This distance is usually about 500 feet.

When the hoop nets are dropped into the water the weight of the iron hoops carries the trap to the bottom. When resting on the bottom the top hoop drops to the same level as the smaller hoop and comes to rest concentrically on the outside of it. The crabs are attracted by the juices of the bait diffused into the water. In order to reach the bait in the center of the net, the crabs must crawl over the outer hoop and webbing onto the smaller hoop. The webbing between hoops allows the large hoop to be hoisted about 14 inches or so above the smaller hoop before the net is raised. The webbing between hoops forms an

angle of 45 to 50 degrees with the smaller hoop. The large meshes allow many of the smaller crabs to drop through, and the larger crabs are kept from crawling out by the steepness of the sides as the trap is being pulled rapidly to the surface. When a trap is raised the boat is brought up against the tide, the float brought aboard, and the slack line pulled in and coiled by hand. When the boat is directly over the net, the line is reeled in over the block on the davit arm by taking a few turns on the small drum, which has been caused to revolve by stepping on the clutch. The line is not allowed to pile up on the drum but is stripped off as fast as it comes in and coiled by hand.

It requires about 2 minutes to raise and set a hoop net. A string of 20 nets takes about 40 minutes to raise and reset. After a string has been run there is usually a wait of 20 to 30 minutes before running

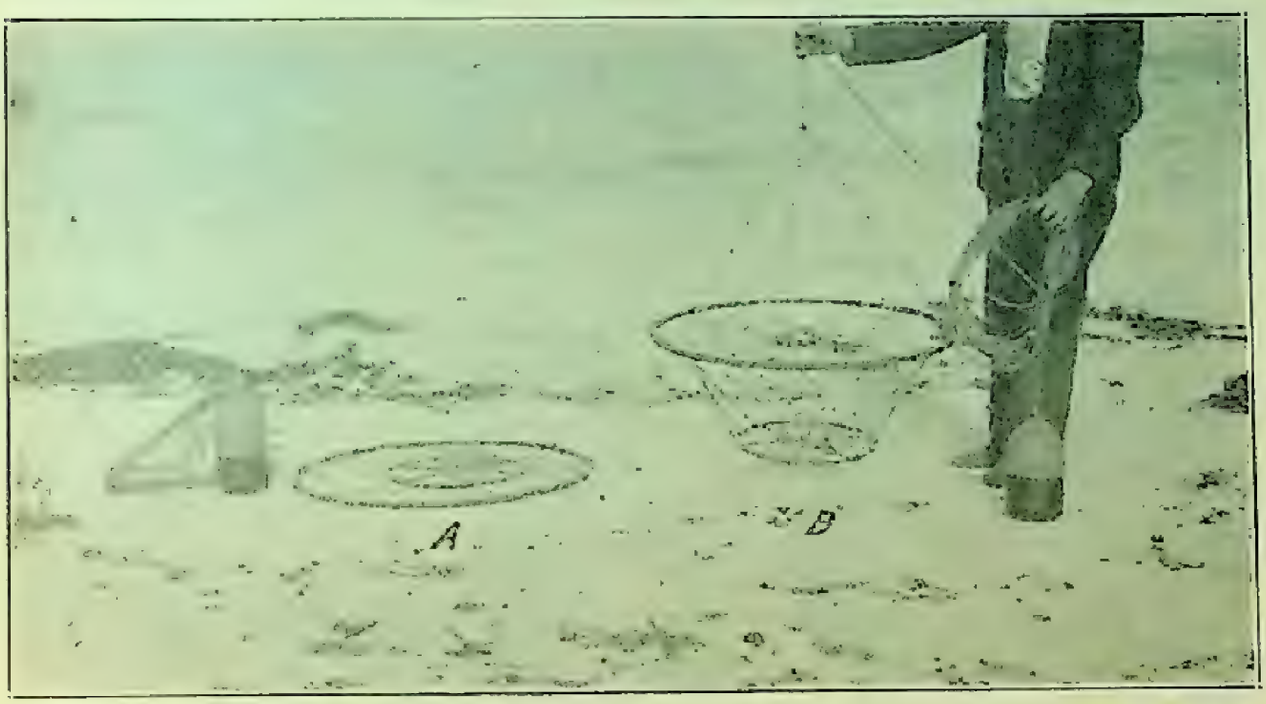


Fig. 20. A standard crab hoop net. This type of trap is used entirely in the San Francisco and Eureka areas. Position *A* on the left demonstrates the trap in collapsed state when in fishing position on the ocean bottom. Position *B* on the right demonstrates how crabs, attracted by the bait in the center, are trapped when the net is pulled to the surface. May, 1934.

the string again. If results are encouraging, a string may be run again immediately.

Legal sized crabs that are taken in the traps are kept under the stern deck. The crabs are thrown loosely into this compartment but are kept with their undersides down. Experienced fishermen claim that a crab will thus survive longer out of water. This is probably because the gills keep their moisture for a longer period when right side up. When a crab is first placed under deck, it scurries around a little and then settles down, usually backed up against something. As successive crabs are thrown in they create a temporary disturbance. Occasionally, a hand to hand encounter takes place with the loss of a leg. On the whole, the semidarkness of the under deck seems to have a quieting effect.

During an ordinary day's fishing, when perhaps 25 dozen legal sized crabs are taken, gasoline and oil amounts to about $1.50. The

cost of bait amounts to about $1.25. Fresh sardines are the preferred bait in the San Francisco area.

LIVE-BOXES

Live-boxes have been part of the equipment of the San Francisco fishermen for many years. (See Fig. 21.) Each fisherman has a live-box tied to the wharf where his boat berths. These boxes are 2 x 4 x 6 feet, outside dimensions, and are constructed of $\frac{3}{4}$ x 3½-inch slats spaced about $\frac{3}{4}$ of an inch apart. They hold approximately 35 dozen crabs when full, but usually not more than 20 or 25 dozen are kept in them at one time. The plan is to empty the boxes in about 4 days to insure active crabs. When in the water, just the top (4 x 6 foot side) is above water, and this side is provided with a door which can be padlocked.



Fig. 21. Live-boxes used by San Francisco crab fishermen. The live-boxes in the foreground and in the background have been hoisted out of the water, and the four live-boxes between are in normal position with only the tops of the boxes showing above water. June, 1934.

When the fisherman returns to port, instead of turning his catch over to be marketed immediately, he drops the live crabs in the live-box where they remain until orders come in from the Crab Fishermen's Protective Association. The reason for the use of the live-box is to hold crabs in excess of the immediate market demand. The yearly demand for crabs has not kept pace with the increase in numbers of fishermen, and consequently the limit of crabs that can be disposed of daily by a fisherman has been rather low; in recent years about 4 to 6 dozen daily. The use of the live-box enables a fisherman to hold several days' limits at one time without duplicating the expense that going out each day would entail. A supply of crabs can also be carried over a period when rough water prohibits fishing.

CRAB FISHERMEN'S PROTECTIVE ASSOCIATION

Catch records since 1918 show that an annual average of 90 per cent of the crabs caught commercially in State waters has been taken in the San Francisco area. All but 2 to 5 per cent of this total of 90 per cent is caught by fishermen that belong to the Crab Fishermen's Protective Association, commonly referred to as the Crab Union. About half of this 2 to 5 per cent is taken by drag boats, the other half by independent fishermen.

The Crab Fishermen's Protective Association was first organized in 1913, with a membership of about 108 boats. The number of boats steadily increased until about 1921, when an apparent scarcity of crabs caused many crab fishermen to seek other lines of fishing for a livelihood. In some instances, they sold their boats. The membership at this time decreased to about 125 boats. At the present time (1934) there are approximately 240 boats belonging to the Association. There are about 25 boats, including drag boats, that fish independently.

A branch of the Association has been maintained at Sausalito for several years. In 1930, 26 boats were members and in 1934, 35 boats were members of this Association at Sausalito. The catches are shipped to San Francisco on chartered boats.

Headquarters of the Association are at the foot of Fishermen's Wharf in San Francisco, where the catch is received. Here, the crabs are purchased by wholesalers and retailers.

Each year an agreement is reached at a meeting between officials of the Crab Union and representatives of the dealers, setting a price that the Union will charge for crabs throughout the season.

Funds for the operation of the Crab Fishermen's Protective Association are secured by assessing each member 3 per cent of weekly check, plus an additional 2 per cent for "revolving fund." From this fund, funeral expenses of members are paid, and if a boat is lost one-third of the cost is defrayed. Any balance in this fund is periodically divided among the members. In addition to the California Division of Fish and Game regulations, the Association has a ruling that a member be assessed $1 for every undersized crab delivered.

MARKETING

Crabs are removed from the live-boxes, as ordered, and placed in ordinary gunny sacks for transportation to market. Two dozen crabs are placed in a sack and this unit is referred to by fishermen as a "sack" of crabs. The Association fishermen take their crabs to the receiving floor of their building where they are receipted and then turned over to dealers. The Association does not ship crabs outside of the San Francisco area. A few dealers handle the out of town shipments, which are mainly to the larger California cities. In southern California, competition is encountered from Oregon crab shippers that undersell San Francisco.

Since the Crab Fishermen's Protective Association has been in operation, the usual price that the fishermen have received for crabs has been $2.00 to $2.50 a dozen.

Perhaps one-third of the total amount of crabs caught by San Francisco fishermen is sold by retail markets located at the foot of Fishermen's Wharf. Here the crabs are cooked each day in large pots

or tanks situated along the curb. Live crabs may be obtained for the same price as cooked crabs. During 1933 and 1934, the retail price of crabs varied, depending upon size, from 25 to 35 cents during the early part of the season and from 20 to 30 cents during the latter part of the season.

EUREKA AREA

The bulk of the crabs taken in the Eureka area are landed at Eureka and Fields Landing. Occasionally, one or two boats land crabs at Crescent City but usually the small amount of crabs disposed of there is shipped in from Eureka or Fields Landing.

FISHING LOCALITY

During recent years, most of the crab fishing in the Eureka area has been carried on off the open coast between Eel River on the south and Mad River on the north of Eureka, a sandy bottom stretch of about 20 miles of coast line. A small percentage of crabs is sometimes taken northward as far as Crescent City. Most of the fishing is carried on in 3 to 10 fathoms of water, but occasionally to 15 fathoms. It is not unlikely that the area most intensively fished at present could be expanded a great deal, perhaps northward to Crescent City, if necessary.

Many years ago before the jetties were constructed across the mouth of Humboldt Bay, crabs were at times taken in great numbers inside the Bay. After the jetties were constructed, crabs gradually became scarcer, and for at least 20 years past the commercial catch inside Humboldt Bay has been rather insignificant. However, several years ago when one of the jetties was broken through by the ocean, large numbers of crabs were taken within Humboldt Bay for a short period of time, according to Nat Groton of Fields Landing.

GEAR

The gear used for capturing crabs in the Eureka area is the same as that used in the San Francisco region. Standard crab hoop nets are used universally.

BOATS

The number of boats that fish regularly throughout the season out of Humboldt Bay is about eight. The fleet is augmented to about 20 by some of the salmon trolling boats that fish crabs during the closed season for salmon. The number of boats fishing for crabs out of Crescent City is usually not more than three, but these do not fish steadily. In earlier years before the export law was in effect, as many as 65 boats in a season operated in this region. Many boats formerly came from San Francisco.

The type of boat that is used regularly for crab fishing is the jig boat. These boats are 20 to 40 feet long and have gas engines of 8 to 16 horsepower. Most of the boats are equipped, as are the boats at San Francisco, with demountable davit arm and block and a foot-clutch-operated drum for pulling up nets. One or two of the boats are not equipped with these conveniences so that the nets must be pulled by hand.

OPERATION OF HOOP NETS

The crab hoop nets are operated in the same manner as they are in the San Francisco area. One or two of the boats, however, are not equipped with davit arms and blocks plus power-driven drum and consequently their operations are slowed up somewhat by the necessity of pulling nets by hand. It is considered good fishing when the yield averages about three legal sized crabs to the trap. Instead of using fresh sardines almost exclusively for bait as do fishermen in the San Francisco area, the Eureka fishermen use fresh horse clams and anchovies mainly. Salt-water perch and sardines are also used on occasion.

A "string" is about 20 traps operated by one man with a boat. Occasionally, two men work together on a boat and then the number of traps is increased to about 30. However, this is infrequent as one man can operate a string almost as well as two men without the requirement of dividing income.

LIVE-BOXES

Each regular fisherman has a live-box in which he keeps several days' supply of crabs. These boxes are of several sizes. The smallest is 2 x 4½ x 9 feet and holds about 60 dozen crabs when full. The largest box is 2 x 8 x 16 feet and holds about 150 dozen when full. The live-boxes are kept not more than about half full. It is necessary to have large live-boxes in this region because of the frequent rough water that is encountered off this northern coast, prohibiting fishermen from fishing on many days. Even during favorable water conditions, the limited market would make it rather unprofitable for a fisherman to go out for only a few dozen crabs each trip.

MARKETING AND THE EXPORT LAW

Market crabs taken in the Eureka area are prohibited by State law from being shipped outside of the coastal districts between the Oregon-California State line and southward to the Mendocino-Sonoma County line, a coastwise distance of about 110 miles. This law was first passed in 1917 and prohibited shipping or transporting crabs taken in Districts 5, 6, 7, 7A, 8 or 9. In 1923, this regulation was amended to prohibit holding crabs in live-cars in the above numbered districts and also District 1½. In 1925, a live-car was defined as any box, crate or pen in which live crabs are kept. The purpose in prohibiting the use of live-cars was to prevent fishermen from accumulating large quantities of crabs at one time and to discourage smuggling which was quite prevalent some years ago. In 1927, District 2½ was included among the above mentioned districts. This was done because District 7 was extended to the southern boundary of Mendocino County, which made an overlap, with the result that crabs were taken off Eureka and brought to Fort Bragg and shipped out. There were one or two other slight changes in the districts, such as abolishing of District 7A which was a separate district of the tide waters of Eel River.

This State law was passed by the Legislature upon complaint of citizens in the Eureka area who declared that most of the crabs caught

in the region were shipped out and that the local crab population was endangered thereby. Also, the local public was compelled to pay exorbitant prices for crabs caught off their own shores.

The greater part of the crabs caught are sold at privately owned crab stands along the streets. There are seven or eight of these stands at Eureka and Fields Landing and one at Crescent City. The stand operators buy their crabs direct from fishermen, and one or two fishermen operate stands of their own. Crabs are also sold to retail markets and shipped to Crescent City. Most of the crabs sold in the Crescent City locality are shipped in from Eureka.

Since 1918, the usual price received by fishermen in the Eureka area has been $1.50 per dozen. In previous years, the price has been as low as 75 cents to $1.00. The highest price since the export law has been in effect was $2.50 per dozen. The retail price for crabs during the 1933–1934 season was 20 to 25 cents apiece. Nat Groton reports that about 30 years ago, when crab fishing was still an uncertain occupation and it appeared that crabs were scarce, fishermen received as high as $6.50 a dozen.

The crab fishermen in the Eureka area are not organized into a union as are the fishermen in the San Francisco area. The export law has set a limit on the number of crabs that can be disposed of and a few regular fishermen can fill this demand.

Before the Division of Fish and Game export law, crabs were shipped out of the Eureka area in live-wells in boats and also alive and dry by railway express as far as San Francisco. No crab export law governs the other regions of California.

MONTEREY BAY AREA

It was not until about 1913 that crab fishing in Monterey Bay became commercially important. Until 1933, the entire catch of crabs from Monterey Bay was landed at the ports of Santa Cruz, Capitola and Monterey. The Capitola fishermen, however, transport their catch to Santa Cruz for disposal. Since 1933, a few Moss Landing fishermen have been landing crabs at Moss Landing and transporting them to Santa Cruz and Monterey for disposal. Altogether, the port of Santa Cruz handles several times the amount of crabs as does Monterey.

FISHING LOCALITY

In the Monterey Bay area, only about a six-mile strip of coast line inside of Monterey Bay is extensively fished. This strip of crab grounds extends from off Moss Landing northward about six miles to a landmark called the Red Sand Hill. Although the bulk of the crabs are caught within this area, decreasingly smaller numbers can be taken northward to Santa Cruz and southward to the Salinas River. During recent years, crabs have been taken only infrequently south of the Salinas River to Monterey, although they were reported fairly abundant during some of the earlier years.

On a few occasions during past years, some fisherman has set his nets off the open coast north of Santa Cruz to Davenport. Although results have proved satisfactory in most cases, this has not become practice because it is less dangerous and less difficult to fish within Monterey Bay.

Crab fishing is carried on from low water mark to a depth of about 35 fathoms. Most of the fishing takes place in 15 to 25 fathoms of water with gill nets. A few Moss Landing fishermen fish their hoop nets from low water mark to a depth of 10 fathoms.

When the season opens on November 15, the gill nets are set in water as deep as 35 fathoms close to the north side of the deep channel in the middle of Monterey Bay. The crabs are caught as the winter months progress, apparently as they come out of the deeper water. During the spring and summer months, the crabs spread out onto the shallower flats. It is at this time that the Moss Landing fishermen operate their hoop nets. It is not unlikely that Moss Landing fishermen will try to develop more of an all-season fishery in the future.

GEAR

Until trammel nets were declared illegal in 1915 in District 17, which includes Monterey Bay, the bulk of the crabs taken in Monterey Bay was captured by means of trammel nets. From 1915 until the present, gill nets have accounted for the bulk of the catch. Trammel nets and gill nets have also accounted for most of the small number of crabs that have been taken off the open ocean north of Santa Cruz to Davenport. In 1933 and 1934 a few experimental trammel nets were used in the Monterey crab fishery to determine the destructiveness of this gear. This work was supervised by the Division of Fish and Game.

During past years, occasionally a fisherman has given crab hoop nets, such as used at San Francisco and Eureka, a brief trial but this method of catching crabs either in or off Monterey Bay was never used consistently until the spring of 1933.* During the spring and summer of 1933 and 1934, a small number of Moss Landing fishermen operated home-made hoop nets very successfully in shallow water between Moss Landing and the Pajaro River.

Crab hoop nets have not been widely nor successfully used in the past, according to Santa Cruz and Monterey fishermen, because of two main obstacles: (1) In certain parts of Monterey Bay, the traps sink out of sight in soft mud and the bait is thereby hidden from the crabs. (2) Hagfish, or "eels" as they are commonly called, eat the bait before it has been given a chance to entice crabs.

Hoop Nets.

The hoop nets used by commercial fishermen in and off Monterey Bay in the past have been the same type as those used by San Francisco and Eureka fishermen.

Hoop nets that the Moss Landing fishermen commenced using in 1933 are home-made affairs, constructed as cheaply as possible. The style of the majority of these hoop nets is patterned after the standard crab hoop net used at San Francisco and Eureka. One fisherman has modified this somewhat by having lower and upper rings of the same size and 6- to 8-inch side walls. He claims that this arrangement prevents the bait from being covered by the upper ring and webbing

* Of the fishermen at Santa Cruz and Monterey, only one, Orv Hartman of Monterey, uses hoop nets with any regularity. Hartman has used a string of hoop nets since 1920 during a few months of some seasons. However, he uses a gill net with greater regularity for catching crabs.

when the nets are used in shallow water where the water action sometimes shifts the nets around. It also gives perpendicular walls when the net is being hoisted and further prevents the escape of crabs.

To make their nets, the Moss Landing fishermen use whatever materials are easily or cheaply obtainable. The larger upper ring of the hoop net may be made of ½-inch iron bar, it may be heavy gauge wire, or it may be an iron hoop of some sort. In some cases, instead of tying the side wall meshes by hand, pieces of coarse webbing are simply cut and fitted. The bait containers are all alike, being squares of about ½-inch mesh galvanized wire screen that is doubled over to form a size of about 6 x 12 inches with the sides laced together and leaving one side open through which the container is baited. The material for each bait container costs about 7 cents. These bait containers are not only cheap but the small meshes protect the bait from being eaten by hagfish which are sometimes encountered in deeper water. Some fishermen have a large cork or two where the three-point suspension from the top hoop joins the main line. This is to keep the bridles off the net. The retrieving line or main line is either of heavy net twine or of ¼-inch rope. The latter is much easier on the hands.

Gill Nets.

Gill nets were originated for the capture of fish. A gill net is a rectangular strip of webbing of uniform size hung flat between a cork line and a lead line so that it suspends itself vertically in the water. When fishes swim into the net, it allows the heads of fish of a certain size range to pass through but prevents their being withdrawn by catching under the gill covers. However, when gill nets are used for the capture of crabs, the crabs do not "gill" but become entangled in the meshes.

The gill nets used for capturing crabs in Monterey Bay are of fairly standard pattern. The size of mesh in different nets varies from 8½ to 11 inches, stretched measure. The webbing is of 6- to 9-thread, medium cotton twine. Linen gill netting was originally tried but it was found that cotton twine besides being much cheaper has more stretch and longer lasting qualities when used for crabs. The nets are made up into sections or "pieces," measuring about 30 fathoms (180 feet) long and about 18 meshes (9 to 12 feet) deep. The webbing is hung between ¼-inch ropes. The upper rope or cork line is threaded with 3-inch corks spaced about a foot apart, and the lower rope or lead line is threaded with 2-ounce leads spaced about 6 inches apart. (Cost of section, complete, 1934, $23.)

Usually, about 10 sections or "pieces" of gill net are tied together, cork line to cork line and lead line to lead line, to form a "string." If the nets are damaged by sharks or porpoises the damaged sections can readily be removed and taken to shore for repair. This arrangement also makes it easier to tan and stow the nets.

When the string of nets is set out, it is anchored on the bottom by a 15-pound dory anchor at each end. When an occasional set is made off the open coast to the northward of Monterey Bay, 40-pound anchors are used at each end. To each anchor, at the junction of the flukes and the shank, is tied a ½- or ⅝-inch rope; the other end of this rope is fastened to a 3-gallon cask that floats at the surface. To this

buoy a "marker" is also fastened by a short piece of ¼-inch rope. This "marker" is usually about a 10-foot length of bamboo pole that is an inch or so in diameter at the base. To keep the marker upright, the basal end is weighted with a few pounds of iron, and at the water line a few feet from the end several corks are threaded or fastened. To the tip of the pole is tied a small piece of cloth, usually light colored for one end and dark colored for the other end of the string of nets.

A fisherman reports that about 1916, a two-lead-line gill net was tried experimentally for market crabs. Instead of a lead line at only one edge of the net and a cork line at the other edge, this net had a lead line at either edge and lay flat on the bottom. The idea was to entangle crabs if they happened to crawl over the net. However, this arrangement did not prove practical.

Trammel Nets.

A trammel net has three walls of webbing hung between a common cork line and lead line. The middle web or net is of finer mesh, loosely hung, and the guard net on either side is of large mesh, hung taut. The mesh of the outside guard nets is usually about three times as large as the mesh of the inner net.*

The principle on which the trammel net works is that a fish swimming into the net from either side passes through the taut large mesh, striking the finer and looser inside mesh through which it can not pass but which is pushed ahead through one of the large meshes on the opposite side thus forming a pocket in which the fish is trapped.

Trammel nets vary from 20 to 40 fathoms in length and 2 to 3½ fathoms in depth. The size of the corks on the cork line and the weight of leads on the lead line are approximately the same as for the gill net.

The manner of setting and raising trammel nets is practically the same as that described for gill nets.

BOATS

The boats used by the gill net fishermen at Santa Cruz, Capitola and Monterey are of the same type and size as those used by the San Francisco fishermen. They are called jig boats and are used for other fishing besides crab catching. Near the stern, usually on the starboard side just off the tiller pit, the gunwale is provided with two holes about 3½ feet apart so that a ½-inch rod bent U-shape on the upper end can be inserted in each hole and serve as a bearing for a roller of about 2½ inches in diameter. The raising of the nets is facilitated by pulling them in over this roller.

At Moss Landing, the hoop net fishermen operate their nets from skiffs that vary in length from 15 to 19 feet, but most of them are 17 feet long. About 6 of the 8 skiffs that were operated regularly in 1934 were provided with 4- to 6-horsepower outboard motors. These skiffs are also used for other market fishing besides crab catching.

* Although the three-walled trammel net is most widely used in California, a two-walled trammel net has been used occasionally. This type has but one wall of coarse webbing on one side of the finer mesh and is therefore effective from but one direction. Also, when gill nets have been made to hang slack by short lengths of twine between the cork and lead lines on either side of the fine meshed webbing, they are classified as trammel nets.

Since crab fishing became commercially important in Monterey Bay, the usual number of boats fishing out of Santa Cruz has been 12 to 20; out of Capitola 3 to 5; and out of Monterey 3 to 10. At Moss Landing there were 12 to 14 skiffs in 1933 and about 8 in 1934.

OPERATION OF GEAR

Gill Nets.

Two fishermen on a boat ordinarily operate a string of gill nets but sometimes one fisherman works alone.

A string of nets is set for fishing as follows: The nets are piled on the port side of the after deck and if room is lacking, the balance is piled on the opposite side. With the boat traveling at slow speed, the float and marker are first thrown overboard and then the anchor, which is dragged a short distance to cause the flukes to dig in, after



Fig. 22. Left view shows how a gill net or trammel net is set for crabs. Center view shows one of the anchors that are attached to either end of the string of nets. Right view, the string of nets is set and all that is visible at either end is the buoy and marker. April, 1934.

which the net is paid out over the side of the stern. When the net is piled, it is simply coiled back and forth with the lead and cork lines together and the webbing bunched opposite. As the net is paid out, the cork line is kept well above the lead line to prevent entangling as much as possible. The string is laid out in a straight line paralleling shore so that the crabs will be intercepted in their foraging movements, which are more intensive at the flow and ebb of tide. The nets are not baited in any manner. Due to the weight of leads on the lead line, the net is carried to the bottom with the lead line touching and the corks keeping the wall of webbing extended upwards. When gill nets are used for crabs, a sufficient number of corks is placed on the cork line so that the nets will slant somewhat with the tides and thereby induce crabs to attempt to cross over the net. When the last

of the string is in the water, the anchor on that end is cast overboard and made to bite in after which the remaining float and marker are tossed over. The only visible evidence of the set net is the float and marker at each end. The owner of a string of nets recognizes his marker or the size, shape or color of his float.

During recent years, it has become a habit with crab fishermen to raise their nets every other day, but they may be raised every day if the market demands. On the other hand, if storms interfere, the nets may be left out for a week or so.

On the days that the nets are raised, the fishermen set out from port so that they can start raising their nets at daybreak. The fishermen all have portable box compasses that are set on the deck in front of them as they stand in the stern pit and guide the boat by means of the short arm or tiller on the rudder. The speed of the engine can also be controlled from the stern pit by means of a small pole that is hooked onto the throttle. On foggy mornings when no landmarks are visible, the fisherman waits until daybreak and then guides his boat by compass and watch to the vicinity of the set net. As the compass course is not too accurate and the float and marker are a small target, the fisherman must sometimes do some scouting after he has run his course for the required time. This is done by circling in ever widening circles until the marker and float are detected.

If there is a surface drift of water or a wind, the net is pulled against the "run" of the sea so that the boat will not drift over the net. The marker and float are first brought on board and then the anchor. This is a continuous operation as the marker is attached to the float, the float to the anchor and the anchor to one end of the net. When the end of the net is aboard, the engine which has been kept idling in the meantime is shut off. The net is then pulled in over the roller on one side of the stern.

The task of pulling net and extracting live, struggling crabs from a gill net is long and tedious. If the net is to be taken ashore, the net is usually pulled as quickly as possible and the catch extracted on the way back to port. This task may be continued for some time after returning to port if the catch is large. It is the practice to take nets to shore about once a week for repairing and tanning. Another string of nets is always kept in readiness to replace those in use. Although the task of disentangling a struggling crab, snarled in a gill net is difficult, the fishermen have devised a system and a tool to meet the situation. The tool resembles a button-hook. In extracting a crab, it is grasped from the rear and the front end placed against the fisherman's body, top side up. Then the meshes of the net on one side of the crab are worked forward and finally over the pincers. The meshes on the other side of the crab are then worked forward in the same manner. The button-hook-like tool is an aid in pulling bars of twine from between joints or from under the carapace and keeps the fingers at a safe distance when in proximity of the ever-working pincers.

As the crabs are extracted from the net, legal sizes are tossed into a compartment on the opposite side of the deck where they are left until port is reached. It is considered good fishing to catch 20 to 30 dozen crabs in a string of 10 pieces of gill net over a 48-hour period.

TRAMMEL NETS

As far as crab catching is concerned, the fishing operations including the setting and raising of nets and the removal of entangled crabs are practically the same for trammel nets as for gill nets. However, as there are two additional walls of webbing, a little more work in untangling the crabs results.

A section or piece of trammel net is usually 20 to 40 fathoms long and 18 to 30 meshes (2 to 4 fathoms) deep. The additional webbing in a trammel net makes its cost about 50 per cent greater than that of a gill net. Several sections of trammel net are tied together to form a string as is the case with gill nets.

LEGLESS CRABS

The method of capturing crabs by means of gill nets (and trammel nets) results in a larger percentage of legless crabs than does the hoop net method. Comparatively few legs are lost while the crabs are bound in the net or when the crabs are extracted from the net by the fishermen. The greatest loss of legs occurs when the crabs, which have been snarled helplessly in the net for many hours, are freed and tossed together on the deck of the boat. Freed, they seem quite antagonistic, perhaps due to their previous condition of helplessness or a desire to prevent a recurrence, and as each crab is tossed into the bunch a temporary disturbance is caused around him. The crabs subside after a short period but not before some hand to hand encounters that sometimes result in the loss of a leg or two.

A leg is not pulled off by brute strength on the part of another crab, but its loss is due almost entirely to the defending crab casting loose the seized leg so that it can free itself. The casting of a leg is reflex action and not subject to the will of the animal. It occurs when the nerve of the leg is stimulated violently, provoking vigorous muscular contraction. With crabs, this separation always occurs between the cephalothorax and the first joint or between the first and second joints. A mass of muscle is usually drawn out of the body along with the leg. Crabs that remain in the ocean with missing legs will rejuvenate these members at the next molt. Of course, if several legs or both pincers are lost, the crab may have difficulty in existing until the next molting period.

MARKETING

There is no union of crab fishermen in the Monterey Bay area. The crab fishermen deliver crabs as they do fish to the established markets for which they have arranged to fish. At Santa Cruz since 1930, about 70 per cent of the regular fishermen belong to a cooperative association that forms a marketing outlet for all their catches from various ocean fishing. This organization is called "Santa Cruz Fisheries" and has its own facilities and operates in the same manner as a wholesale and retail market.

Upon returning to port, a fisherman at Santa Cruz or Monterey unloads his catch of crabs loosely into a hoop net or box container lowered from the dock of the market. At Capitola and Moss Landing, the crabs are placed loosely in open boxes and transported to market.

Previous to the 1933–1934 season, no distinction was made between crabs with legs missing and whole crabs. A large percentage of crabs with missing legs would bring varying prices. During the 1933–1934 season the dealers in the Monterey Bay area adopted the practice of segregating crabs having two or more legs missing and paying but one-half price for them. Such crabs were designated as "cripples." Since 1933, the regular price paid fishermen by dealers has been $1 a dozen for whole crabs and 50 cents a dozen for "cripples." Since about 1913, when crabs were first caught in large enough numbers in the Monterey Bay area to assume commercial importance, the usual price that the fishermen received has been about $1.25 per dozen. The highest price during this period was about $2.50 and the lowest about 65 cents a dozen. Around the Monterey Bay area crabs of equal size retail for about the same price as at San Francisco. "Cripples," however, have retailed for as low as 12½ cents apiece.

In the spring and summer of 1933, when crabs were first fished commercially by Moss Landing fishermen, all the catches were placed in the hands of a man who operated a lunch wagon on the wharf. He, in turn, disposed of the crabs to dealers in Santa Cruz and Monterey. The following year, the fishermen disposed of their own catches, trucking to dealers in Santa Cruz and Monterey. The Moss Landing fishermen have been kept on a limit which is usually four to six dozen a day. They have had little trouble in supplying such limits and could probably supply the entire Monterey Bay area demand from the time they start intensive operations in the spring until the close of the season on July 30. These fishermen receive prices that are prevalent at Santa Cruz and Monterey, but sometimes surplus catches have been sold as low as 65 cents a dozen.

A certain amount of market crabs is shipped from Santa Cruz and a lesser amount from Monterey. Shipments are made to San Francisco, where Monterey Bay crabs are usually sold "picked," *i.e.*, the meat without the shells, and to other important centers such as San Luis Obispo, Fresno, Los Angeles, and San Diego. Crabs from Monterey are sold under San Francisco prices as much as 50 cents a dozen.

LIVE-BOXES

Live-boxes are not a part of the equipment of Monterey Bay crab fishermen as is the case with San Francisco and Eureka area fishermen. Live-boxes can not be satisfactorily used in Monterey Bay because of the bouncing around that the crabs receive when the Bay becomes rough. This is especially true when the box is only partially filled. In San Francisco Bay and Humboldt Bay, the open sea condition is not encountered.

For about a month during 1934, Santa Cruz Fisheries tried two live-boxes, anchored to a float off their market, but found that they could not be used satisfactorily. These boxes were 1 x 6 x 7 feet and constructed of 1 x 6 inch lumber spaced about an inch apart. They held about 25 to 30 dozen crabs each and were used to take care of surplus crabs for which the association lacked immediate orders.

During 1933 at Moss Landing, a live-tank was used on the wharf in which the various catches were collected daily for immediate trans-

portation to Santa Cruz and Monterey. At Monterey during 1934, one market was provided with an inside live-tank in which surplus crabs were kept for a few days.

DRAG BOATS

Drag boats working in the San Francisco and Monterey areas bring in occasional catches of market crabs which have been taken while hauling for flatfish. These amounts vary from time to time, but over a period of a year this comprises ½ to 2 per cent of the State total. On some occasions, one drag net outfit may bring in several hundred dozen crabs, temporarily glutting the market. In the Eureka as well as the San Francisco area drag boats catch but few crabs as they are compelled to drag outside the three-mile limit.

During recent years, there have been from five to seven regular drag net outfits operating in California waters. Since the fall of 1933, drag nets have been permitted within the three-mile limit along only about one-third of the coast line of California or from Pigeon Point southward to the Santa Barbara County line. No dragging is permitted inside of bays except Monterey Bay outside of the 25-fathom line.

LOS ANGELES AREA

The market crab is not exploited south of Monterey Bay because of its scarcity. In southern California waters, it is taken rarely, but several relatives of the market crab, collectively called rock crabs, appear in fairly large numbers in these waters. In the Los Angeles area, these have been exploited in recent years by a few market fishermen as a side line to other forms of fishing. Although this total has increased considerably during the past season, it is still less than one-half of 1 per cent of the annual State total of crabs landed commercially.

Although the so-called rock crabs are also present in large numbers to the northward, they are not utilized commercially from Monterey Bay northward because of the abundance of the more desirable market crab. They are used for home consumption to some extent all along the California coast. Commercial fishermen to the northward save only the claw legs when crabs are at times taken in numbers in their nets.

SPECIES OF ROCK CRABS IN LOS ANGELES AREA

There are three species of rock crabs taken commercially in southern California waters and all are generic relatives of the more northern market crab.

Following, these crabs are listed in the order of their importance together with the common name used by fishermen and a brief color description of each:

Cancer antennarius. Rock crab.

Color dark red. Under parts yellowish white, spotted with red. Taken from British Columbia to Magdalena Bay.

Cancer anthonyi. Yellow crab.

Color brownish-tan. Under parts whitish, washed with yellow. Taken from southern California to Magdalena Bay.

Cancer productus. Red crab.

Color medium red. Under parts whitish, mottled with light orange-red around edges. Taken from Alaska to Magdalena Bay.

These crabs have a somewhat oval-shaped carapace that is saw-toothed on the front margin as in the market crab, but instead of the whitish-tipped pincers as in the latter, all have blackish-tipped pincers.

MARKETING

Rock crabs are sold to fish peddlers and to markets, principally in Los Angeles, San Pedro and other coastal towns. A few crabs, mainly *C. anthonyi*, are delivered at Newport. The crabs are sold either by weight or by the dozen, the markets usually buying them by weight. Fishermen are paid 3 to 5 cents a pound. The crabs average slightly under 1 pound apiece, the largest ones weighing up to 1½ pounds. When sold by the dozen to peddlers usually, the fishermen receive 25 to 40 cents a dozen. These crabs are retailed from 10 to 12½ cents apiece, depending upon size. At some markets, crabs are sold on consignment, the marketman paying the fisherman later only on the poundage that he has been able to sell.

METHOD OF CAPTURE

In the Los Angeles area, rock crabs are captured in lobster traps, bass traps and hoop nets. The lobster trap is a box made of slats or chicken wire and of a shape such that will not easily tip over. The entrance, which is on top, is a tapering funnel that ends midway in the box. This arrangement permits easy entrance but prevents exit. The bass trap is a box-like structure similar to the lobster trap. However, instead of only one entrance funnel on top, it has an entrance funnel at either end. This constitutes the chief gear by which rock crabs are captured in the Los Angeles area.

During the past season, one fisherman has been using crab hoop nets almost exclusively. These hoop nets are the same as described for the San Francisco area but are raised by hand.

Fresh fish heads are the most popular bait used in these different traps. Baited traps are left for a day usually and the hoop nets are raised every 5 to 20 minutes. Most of the crabs are taken close to shore and sometimes from piers as is the case when hoop nets are used. During the lobster season, a certain number of crabs are caught off shore to a depth of 25 fathoms in lobster traps.

MARKET CRABS SHIPPED INTO SOUTHERN CALIFORNIA

The market crab (*Cancer magister*) that is found in southern California markets is not taken locally but is shipped in from Oregon and central California ports, mainly San Francisco, Santa Cruz and Monterey. Northern California ports, mainly Eureka, are prevented from shipping crabs because of the previously explained export law in some of the northern districts. Probably as many crabs are shipped in from Oregon as are shipped in from central California ports. The Oregon crabs are graded by wholesalers as small, medium and large and are sold under California wholesale prices. For example, during 1933–1934, medium-sized Oregon crabs could be obtained by dealers

for $1.40 a dozen, whereas the San Francisco price was $2.05 a dozen mixed, and Monterey Bay prices were $1.50 to $1.75 a dozen mixed. These prices are f.o.b. port of origin.

The Oregon crabs are all shipped cooked and iced. Most of the San Francisco and Monterey Bay crabs are shipped cooked and iced, but some are shipped alive and dry. Cooked crabs will keep in good condition for about two weeks on ice. Crabs will keep alive out of water for about 24 hours if kept cool and in a position that will prevent moisture from draining off the gills.

Altogether, southern California does not dispose of very many market crabs. This is because there is another large and desirable crustacean, the spiny lobster, which can be obtained locally in abundant numbers.

THE HARVESTING OF KELP IN CALIFORNIA*

By W. L. Scofield

During the World War, kelp was harvested in southern California in huge quantities as a source of potash for explosives, but since that time only one or two small plants have operated on a limited scale. These small operations, however, have led to several misconceptions on the part of some of the observers, and it is the purpose of this article to comment upon a few phases of the kelp harvesting questions that have been up for discussion recently.

Several of the many species of marine algae or seaweeds are utilized for one purpose or another in California, but one kind in particular grows in dense masses forming large beds in the shallow water. This species is a large plant with big flat leaves supported at the surface of the water by means of bladders or floats. This plant, sometimes called "long bladder kelp" is more commonly known as "giant kelp" (*Macrocystis pyrifera*). This is the species which is harvested by means of a "kelp cutter," or barge equipped with cutting knives like the old fashioned grain mowing machine. These knives trim off the portion of the plant floating at the surface of the water.

The opinion has been expressed by some persons unacquainted with the facts that kelp is being promiscuously harvested by unauthorized companies, thus destroying the kelp beds and spawning grounds of fishes, endangering the sport fishing and causing a nuisance on the bathing beaches of the southern part of the State. The kernel of truth in this opinion is minute. In the first place the harvesting of kelp in California is governed by State law, which defines certain restrictions and delegates to the Division of Fish and Game the authority to lease kelp beds for harvesting and to regulate the cutting operations on both leased beds and on beds not under lease. This authority includes the closing to cutting of any beds for a period in order to safeguard a bed against possible injury. In other words, promiscuous cutting is not allowed and each harvesting machine is operated under legal restrictions and according to regulations laid down by the California Division of Fish and Game.

The Division of Fish and Game, as a conservation body, naturally gives first consideration to the safe-guarding of our supply of marine fishes and would not sanction kelp cutting if it destroyed spawning grounds or interfered with either sport or commercial fishing. The number of persons benefited and the revenue derived from kelp cutting are small. By contrast, the value of our crop of fish is more than 14 million dollars annually, and several thousands of our citizens are engaged in fishing either for sport or for a livelihood. The cutting of kelp would not be allowed if we were not sure that kelp as a natural resource could be utilized without injury to fish or fishermen. Kelp beds are a valuable though minor asset and it is the policy in this State

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to so regulate the harvesting that the beds will be improved and perpetuated rather than injured or destroyed.

A great amount of information about kelp and its cutting has been accumulated by the Division of Fish and Game over a period of nearly twenty years. During the World War, kelp harvesting was about fifty times as heavy as at present and the beds were maintained in a thriving healthy condition. The revenue derived from this heavy cutting for war purposes was used in a study of the subject by both State and Federal investigators. Much has been published on the subject. An excellent summary of the knowledge gained on *Macrocystis* was issued by the United States Department of Agriculture as Bulletin 1191, "Potash from kelp: early development and growth of the giant kelp, *Macrocystis pyrifera*," by R. P. Brandt.

The State law allows cutting of kelp only a short distance under the surface of the water so that the body of the plant will not be injured and so that the shorter branches may grow up in a few weeks to take the place of the longer branches which have been trimmed. The occasional trimming of the old branches at the top of the water has a beneficial effect on the beds, resulting in the replacing of old fronds by a vigorous new growth. Many land plants are improved by judicious trimming but this is even more true in the case of kelp because in the old branches the leaves are held at the surface of the water by hollow gas-filled floats. After a time these floats wither, become punctured and allow the branch to sink, thus smothering the younger shoots below it. This sloughing of older portions of the plant is characteristic of the giant kelp and occurs even in young healthy growth if the temperature of the ocean water rises much above 77 degrees F. The worst enemy of kelp is a bacterial disease known as "black rot" which attacks the older leaves and stems at the surface of the water. It has been found that trimming off these older leaves is the best means of combating black rot and that periodic trimming results in a thicker and more healthy growth of kelp.

Kelp cutting could more properly be called "trimming" as the surface fronds are merely trimmed off without injury to the main body of the plant and without destroying the shelter and hiding places for fish. A few fishes, that seek protection in kelp, are naturally frightened away a short distance while the harvesting machine is operating but they return again to the beds when the noise ceases and find their accustomed shelter among the leaves and stems of the plants.

Fish do not appear to spawn on the upper branches and leaves of the kelp, as examination of many tons of harvested kelp has not revealed fish eggs on the plants. Kelp leaves are usually spotted with colonial animals called bryozoans which form a protective calcareous crust that is marked like a golf ball, and these colonies of animals are often mistaken for fish eggs by people who give a hasty glance without stopping to examine the white mass on the kelp leaves. Most marine fishes spawn in the open sea but a few species spawn in shoal water and the larvae and young of some of these seek shelter in kelp beds for a period during their lives. This is an additional reason for maintaining kelp beds in a healthy condition by occasional trimming under proper regulation.

It has been shown that proper trimming maintains the kelp beds in a more healthy condition and tends to carry beds over the period of summer sloughing by inducing vigorous new growth. It should be pointed out that the trimming of surface leaves in no way injures the reproduction or fruiting of the kelp plant itself. The kelp spores (corresponding to seeds in land plants) are borne on short branches near the base of the plant and are not touched when the surface leaves are trimmed. The spores when ripe swim about in the water till they stick to a suitable surface and then sprout into a new plant. In about six months the plant is a foot and a half high and in a year its leaves are floating on the surface of the water. New plants establish themselves best where there are suitable rocks for their "holdfasts" or roots and where the water is 40 to 50 feet deep. Plants live a number of years and are not killed by the summer sloughing. Destruction of plants is due chiefly to being torn loose from the rocks during storms. Plants with an excess of old leaves at the surface with many punctured floats or weakened by black rot are more apt to be torn out by rough seas so that proper trimming to maintain healthy beds tends to lessen the losses due to storms.

By proper methods of harvesting, a kelp bed may yield a good crop by having the tips of the fronds at the surface of the water trimmed off, and the younger shoots will grow out rapidly to replace the portions cut away. The replacement is so rapid in a healthy bed that the cutting may be repeated every three months. For beds of less vigorous growth, the cutting should be at intervals of four to six months. The time of year influences the frequency of cutting as growth is more rapid when the water is colder, as in the spring and fall months.

So far the argument has been in favor of periodic trimming of kelp beds but there is, however, one objection. Some tip-ends of branches are very apt to escape the harvester and be washed ashore, so that where the beach is used by bathers this is objectionable. Proper methods of harvesting may reduce this to a minimum by leaving a portion of the bed inshore to catch the drifting leaves that escape. Then a final cut of this inshore portion would clean up nearly all of the drifting material. Where so many people use the beaches, as in southern California, and the cut ends of kelp come ashore in sufficient quantities to be a nuisance, the difficulty could be solved by confining the harvesting only to those months of winter when the beaches are not being used by bathers.

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THE CALIFORNIA OYSTER INDUSTRY

By PAUL BONNOT

(Photographs by the author)

The California oyster industry, which in the latter part of the last century was a flourishing business, had declined to a very small portion of its one time opulence by 1910 and from that date until 1931 consisted merely of importing oysters from outside the State and reselling them. Beds were maintained only to hold live oysters until sold and no attempts were made to grow oysters.

In 1931 a cooperative agreement was entered into between the California Division of Fish and Game and the U. S. Bureau of Fisheries whereby an investigation of the oyster resources and available growing areas was to be made, with a view to encouraging the culture of oysters in California. A biologist from the U. S. Bureau of Fisheries and one from the California Division of Fish and Game were assigned to the work. A preliminary survey was made during the latter part of 1931 and experiments, based on the findings, were begun in several California bays. On July 1, 1933, the cooperative arrangement was terminated and since that time the California Division of Fish and Game has carried on the project.

As there was some confusion regarding the ownership of the water bottoms in some of the bays, a check was made to determine what lands were still owned by the State and what was held under State patents. The old oyster law of 1873 was found to be inadequate and the Legislature of 1933 passed a new law, sponsored by the Division of Fish and Game, which takes account of and deals with present day conditions.

The larger part of the inshore waters of California support a growth of native oysters (*Ostrea lurida*). Three other species have been introduced, the eastern oyster (*O. virginica*), a Japanese (*O. gigas*) and a Mexican (*O. vealchii*). Some of the California inlets are closed off from the ocean for long periods during the summer by the formation of bars across their mouths. The water behind the bars either evaporates and becomes alkaline or receives fresh water which reduces the salinity below the point necessary for oysters. Some shallow bays closely connected with the ocean which receive clean cold water on each floodtide do not support native oysters but would probably be suitable for the growing of Japanese oysters.

HISTORY

An historical account of the oyster industry of California must deal almost entirely with exotic species. The native oyster has been utilized commercially since the days of the Spaniards but no worth while attempt at any form of culture was ever made. The natives were merely taken from the natural beds until the introduction of other and larger species thrust them into the background.

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In recent years the sale of oysters in California has been confined to eastern oysters, shipped market-size and held in San Francisco or Tomales bays and to Olympia oysters, shipped from the State of Washington. There is no particular reason why the California native oyster could not compete favorably with Olympias except that in both California and Washington the old-time oysterman, until very recently, clung to the trial and error method of culture, and natural conditions in the



Fig. 23.

State of Washington have been such that these methods were effective there.

The first introduction of a foreign oyster on a commercial scale was in 1868 when the Mexican Oyster Company started importing Mexican oysters to San Francisco from Altata and Acapulco. The oysters were shipped by steamer and sold at the dock for 25 cents each. A notice was posted several days in advance of the steamer's arrival. This business was not very profitable as many of the oysters died during the trip and in 1870, when the eastern oysters began to be shipped to

San Francisco on the newly completed transcontinental railroad, the Mexican company went out of business. Mexican oysters were again imported during 1897–99 by Eli Gordon of San Francisco but the conditions arising from the Spanish-American War caused him to discontinue the business.

During 1870 A. Booth of Chicago shipped three carloads of eastern oysters to San Francisco. Most of these were sold at once and those remaining were laid out in the bay. Booth sold out to the Morgan Oyster Company in 1871 and passed from the picture.

The first oyster beds were located at Sausalito, Point San Quentin, Sheep Island, Oakland Creek and Alameda Creek. These beds were soon abandoned and by 1875 all the beds were located in south San Francisco Bay. In 1872 Corville and Company laid out a bed just south of Point San Bruno. After operating here for several years they sold to Swanberg and West who worked the ground until 1885 when it was absorbed by the Morgan Oyster Company. In 1884 Doane and Company established a bed at North Belmont and the next year sold it to Morgan Oyster Company. In 1877 M. B. Moraghan made a start in the oyster business and controlled several beds, the most important being at Coyote Point, near the Morgan Oyster Company bed. By 1885 we find only two companies engaged in the oyster business; Moraghan with two or three beds and the Morgan Oyster Company controlling six. The Morgan Oyster Company beds at this time were located at Dumbarton, San Bruno, Millbrae, Alvarado, North Belmont, and South Belmont. The Alvarado station was abandoned in 1890 as it was too exposed to strong winds and heavy seas.

Moraghan dropped out some time later and the Morgan Oyster Company controlled the oyster business until 1921 when they went out of business and the Consolidated Oyster Company took over their interests. The Consolidated Oyster Company is still carrying on, maintaining until 1929 the old Millbrae bed which was started by Morgan Oyster Company in 1874, and now operating a bed at Oyster Point.

The first oysters shipped by Booth in 1870 were market size. This was found to be unprofitable as the expense of shipping adult oysters was excessive. Morgan Oyster Company started the practice of shipping eastern oyster seed and planting them in San Francisco Bay, and this method was successfully maintained until about 1900. The prevailing opinion at the time was that the eastern oyster would not spawn or set seed in San Francisco Bay because of the low temperature. However, no concerted effort was ever made to catch any eastern seed oysters, and as a matter of fact eastern seed oysters did set seed in small quantities on the eastern side of the bay. During the 90's an average of 100 carloads, of 90 barrels each, of seed oysters were shipped to San Francisco yearly.

About 1900 some unknown factor or factors caused a radical change in the southern end of San Francisco Bay which acted unfavorably on the oyster beds. The eastern seed planted there took much longer to reach a fair size and they were thin, watery and unfit for market. As the old-time oystermen knew little of the biological side of their business and ran it by a trial and error method, their only recourse was to look about for other bedding grounds. They decided to try Humboldt Bay.

Humboldt Bay had been tested for eastern oysters by the U. S. Bureau of Fisheries, which in 1896 planted 25 barrels of 3 and 4 year old easterns from Princess Bay and East River, New York. The returns of this plant were negative. About 1910, three men—Louis Hegburg, Ivan Berggren and Olaf Thoresen—established small beds of natives in the northern end of the bay and carried on the business on a small scale. They sold their holdings to the Morgan Oyster Company in 1911 and that company immediately shipped in large quantities of eastern oysters only to find that the local conditions were unfavorable as the U. S. Bureau of Fisheries had already demonstrated. By 1912 they had lost $90,000 on the venture and abandoned their holdings in the bay.

In 1911 while the Morgan company were taking out their oysters as fast as the market conditions allowed, Mr. Louis Eaton, now a member of the Consolidated Oyster Company, planted 250,000 adult eastern oysters in south Humboldt Bay, where conditions are a little different from those prevailing in the northern end of the bay. However, comparatively few of these oysters were ever recovered. Humboldt Bay was given up by the oystermen and no attempt was made to do anything more there until 1932.

Oyster planting in Tomales Bay started at about the same time as that in San Francisco Bay. At Millerton, on the eastern side of the bay, 17 carloads of eastern oysters were laid out by Weinard and Terry, in 1875. They simply held them there and sold as the market permitted until all were disposed of. Easterns were again planted in 1907 by Eli Gordon, who staked several small beds. Gordon later sold his holdings to J. McNab and G. Smith, who in turn sold to the Pacific Coast Oyster Company, which still owns the beds and holds eastern and Olympia oysters there. The Consolidated Oyster Company put in a small bed at Blakes Landing in 1917, which is now abandoned.

SURVEY

Oysters grow within certain defined limits of temperature, salinity and current. Some areas produce in abundance the microscopic animals and plants on which the oysters feed, while others may be almost sterile in this regard. A mud bottom is generally better for growth than any other, but if it is too soft the young oysters will smother before they become large enough to maintain themselves on the surface. In the following account of the bays and inlets on the California coast all such matters have been considered, for each place, before making recommendations concerning it.

LAGOONS AND BAYS OF NORTHERN CALIFORNIA

Lake Earl, Big Lagoon, Stone Lagoon and Freshwater Lagoon are bodies of water along the northern coast of California not far south of the Oregon line. Each is separated from the ocean by a sand bar which effectively cuts off the ocean in summer, while seas wash over it during the winter storms. In this region the rainfall is sufficient to more than replace the water lost by evaporation. Water from the lagoons evidently seeps through the sand into the ocean and, although the water is generally quite saline, at the end of the winter storms the salinity is rapidly lowered by drainage and remains nearly constant during the

summer and fall. Freshwater Lagoon is effectively shut off from the ocean and, as the name signifies, is not mixed with an appreciable amount of sea water. The salinity of the other lagoons is but little higher.

These areas are not suitable for the culture of oysters unless they were kept open to the ocean for at least the major part of the year. This would probably only be possible by some culvert arrangement and the results would probably not justify the expenditure.

Humboldt Bay.

Humboldt Bay is about 14 miles long and has a maximum width of 4 miles. The high tide area is about 25 square miles. It is in the form of two shallow basins, the northern one being 4½ miles long and 4 miles wide and the southern 3½ miles long and 2¼ miles wide, connected by a deep channel 6 miles in length and ¾ of a mile in width.



Fig. 24. The type of dike being built in Humboldt Bay. July 7, 1932.

The ocean entrance is near the junction of the channel with the south basin. Each basin is cut by two main and a few smaller channels which drain the flats. Much of the bottom is exposed at mean low tide. Some of the area is densely covered by eel grass while the remainder is bare mud.

The native oyster is indigenous to Humboldt Bay and there are several natural reefs of some extent in the channels and smaller beds on the mud flats. With a little hardening most of the bottom is usable for oyster growing. This has been accomplished, on a small scale, with sand, gravel and shell and these areas have been diked after the methods in use in Puget Sound. The natural reefs have been tonged and the oysters obtained have been laid out on the diked areas as brood stock. Experiments have been conducted with various types of spat collectors, mostly cardboard egg crate fillers coated with cement. In 1933 the set was a comparative failure but in 1934 a very good one was obtained. It was considered desirable in the beginning to limit the activity on Humboldt Bay to the growing of native oysters, inasmuch as it had

been demonstrated that eastern oysters were an uncertain proposition and also because no imported pests were in the bay. The improved areas have been worked with this in view. About 10 acres of bottom, all on privately owned ground, has been brought under dike and more of this type of improvement is in contemplation.

Bodega Lagoon.

This body of water is the northern end of Bodega Bay and is partially closed off from the main portion of the bay by a low sand bar. The lagoon has a total area of about 500 acres, about half of which is exposed at mean low tide. It receives very little fresh water and is filled by each flood tide with clean cold ocean water. The bottom is a very firm mixture of mud and sand. Clams of several varieties grow abundantly but no oysters were found. Several plants of Japanese seed oysters were made in 1932. The areas selected were not favorable and very little return was obtained. A few of the survivors from one plant were taken up and again laid out on a gravel beach near shore, where they have done very well. Nothing further has been done in Bodega Lagoon to date.

Estero Americano.

The Estero Americano is a narrow inlet about 8 miles long which enters Bodega Bay about 6 miles south of the mouth of Bodega Lagoon. The bar at the mouth is completely closed for a large part of the time and tidal action in the estuary is limited to the small amount of vater which flows through the sand. Evaporation is very rapid and he water in late summer is strongly alkaline. In winter the fresh vater run-off from the surrounding territory is of considerable magnitude and the bar is usually broken. It is probable that oyster culture could only be carried on if it were certain that the bar could be kept open constantly. This does not appear to be expedient.

Estero de San Antonio.

This estuary is immediately south of the Estero Americano and the prevailing conditions are similar in their probable effect on the culture of oysters. It is 12 miles long, the bar at the mouth is closed most of the time and the water contains an excessive amount of alkali. The area is not recommended for the cultivation of oysters.

Abbott's Lagoon.

Abbott's Lagoon is a small body of water on the north side of Point Reyes. It is separated from the ocean by a high sand bar and is very seldom open to the ocean. It contains no wild oysters and it is doubtful if any could be grown there.

Drake's Estero.

Drake's Estero is a large lagoon at the west end of Drake's Bay. The entrance is a narrow channel through a sand bar on the southwest side of Point Reyes. Several arms extend far back into sunken valleys and the shores in most places rise steeply from the water's edge. The bottom at the mouth is pure sand, which gradually changes to a soft

mud in the upper ends of the arms. No oysters were found growing there. Several small plants of Japanese seed oysters were made in 1932. The oysters grew remarkably well and in five months were about two-thirds market size. A project of an experimental nature on a much larger scale is now being promoted and there seems to be no reason why this lagoon should not produce a good quality of oysters in considerable quantity.

Tomales Bay.

Tomales Bay is a long inlet opening into the ocean at the southern end of Bodega Bay. It is 13 miles long and has an average width of nearly a mile. The depth will average about 20 feet. The shores are quite steep and the tideland area is limited. Wild native oysters are found in the bay south of Tom Point. They occur in a zone having a vertical depth of about three feet, from about two feet above mean low tide to one foot below. They are able to maintain themselves only on the rocky shores where the stones to which they cling offer protection from the sting rays.

The Pacific Coast Oyster Co. has a staked bed two miles north of Millerton, on the east side of the bay, which has been used for some years for holding adult easterns. During the last two years several plants of Japanese oysters have been made in this bed and have done very well. The Pacific Coast Oyster Co. has also done some work on the local native oysters and has used them at times when the Olympias were scarce.

Any experiments with improved methods of culture for oysters in Tomales Bay will be carried on with the knowledge that the bay is heavily infested with pests from the east coast. The eastern drill (*Urosalpinx cinerea*) and the slipper shell (*Crepidula fornicata*) have been introduced through the shipment of uninspected oysters. They are now found in all parts of the bay where the oysters occur. They will have to be considered as permanent residents of the bay and the cost of oyster culture will be correspondingly increased.

Bolinas Lagoon.

Bolinas Lagoon is a cigar-shaped bay a few miles north of the Golden Gate. It is about four miles long and not over one-half mile wide. It is very much like Bodega Lagoon and could probably be utilized in the same way, though there will be more of a pollution problem. The bottom is exposed at mean low tide and is covered with fresh ocean water on each flood tide. Japanese oysters would no doubt thrive here but it can not be recommended for growing natives.

San Francisco Bay.

San Francisco Bay has supported a crop of native oysters for ages. The shells have been deposited for centuries and the accumulation is now being used in the making of cement. In recent years of light rain the native oysters have extended their range and are now found well up the sloughs and in other places where they were not able to maintain themselves a few years ago. In some places development is affected by some unkown factors and the full grown oyster is not marketable. If the bay were not so thoroughly infested with eastern drill and slipper

shell it might be possible to grow the seed to plant elsewhere and thus use portions of the bay for seed grounds.

Eastern oysters are held in the bay until marketed, and a few Japanese oysters have been grown. Recent ventures have not proved to be marked successes and it is probable that other areas will be used in the future. Portions of San Francisco Bay are free from sewage but great areas are contaminated and must be avoided. In clean areas where native oysters develop to commercial size, some effort may be made to improve natural conditions but no great amount of time or energy should be spent in San Francisco Bay until sanitary conditions improve.

Elkhorn Slough.

Elkhorn Slough, six miles south of Watsonville in Monterey County, consists of two long, narrow channels which unite about one-half mile from the ocean. The main arm of the slough is about six miles long and



Fig. 25. Japanese oysters grown on ropes suspended from floats, at Elkhorn Slough. February 7, 1933.

varies in width from 50 to 100 yards. The slough is open to the ocean at all times and therefore subject to the tide flow.

Because of its accessibility and freedom from pollution, the slough has been used for oyster experimentation for some years. Native oysters are indigenous. In 1923 small eastern oysters from Texas were planted but they gradually died or disappeared. In 1929 Mexican oysters were tried but they also failed to survive. Japanese oysters were introduced in 1929 and as they showed up well, 243 boxes of Japanese seed, set on tarred rope, were put out the following year. The rope was handled after a method developed in Japan, by cutting it into suitable lengths and hanging it from rafts. From this plant of 243 boxes some 9000 gallons of oyster meat was harvested and sold. The growth of these oysters was remarkable, requiring only eight months from the time of planting to reach market size. By the next spring the

few oysters that remained were too large for the market, which calls for an oyster of 200 count (200 to the gallon). Twenty-five barrels of eastern oysters were planted in January, 1932. Some were laid out on the bottom and some were strung on copper wire and hung from floats. They have shown a good growth but have not equaled the Japanese in size. Experiments have been carried on for the past two summers at Elkhorn in an endeavor to obtain a local race of Japanese oysters, but so far without success. Other experiments, however, have resulted in a heavy set of native oysters, and with a little attention the slough should be able to produce a good grade of native oysters in fair quantity.

LAGOONS AND BAYS OF SOUTHERN CALIFORNIA

Morro Bay.

Morro Bay is a large lagoon opening into the ocean a few miles north of Port San Luis. The ocean entrance to the bay is on the north side of a high volcanic plug known as Morro Rock. The bay is about four miles long and two miles across at the widest place. The area at high tide is about four square miles. Nearly all of the bottom is exposed at mean low tide. Eel grass grows in great abundance in the central portion. Near the mouth the bottom is of pure sand which changes gradually to mud toward the head of the bay. There are no natural oyster beds in the bay. Several boxes of Japanese seed oysters were laid out in the bay in 1932 but little return was obtained from them. Though at first sight the bay seems favorable for oysters, several factors would present very real difficulties. The bay is very shallow and the bottom more or less shifting. With constant attention Japanese oysters might grow, but it would not be advisable to do more than cautiously experiment at present.

Mugu Lagoon.

Mugu Lagoon lies just north of Point Mugu and south of Hueneme Point. It is a long narrow body of water, parallel to the beach and separated from the sea by a low sand bar. One arm is about a mile in length and the other three miles. It is said that eastern oysters have been planted in Mugu Lagoon but no records of the enterprise are available. There is a good growth of native oysters at present. Mugu Lagoon is the most northern of several bays and lagoons which lie to the south of Point Conception. At Point Conception the ocean temperatures change, the temperatures to the south being about 5° Centigrade higher than those north of the point. For this reason oysters grow rapidly during the summer months and are generally not marketable except for a couple of months during the winter. Most of the southern lagoons receive no fresh water at all during the summer and are flushed out by violent freshets during the winter, which is not conducive to oyster culture.

Alamitos Bay.

Alamitos Bay opens to the ocean on the Los Angeles-Orange county line. At one time this bay contained large native oyster beds but these have been almost destroyed by dredging and pollution from nearby

oil wells. The bay at present is not suitable for the production of oysters.

Anaheim Creek.

Anaheim Creek empties into the ocean just south of Alamitos Bay, and about 10 miles south of San Pedro. It is made up of many

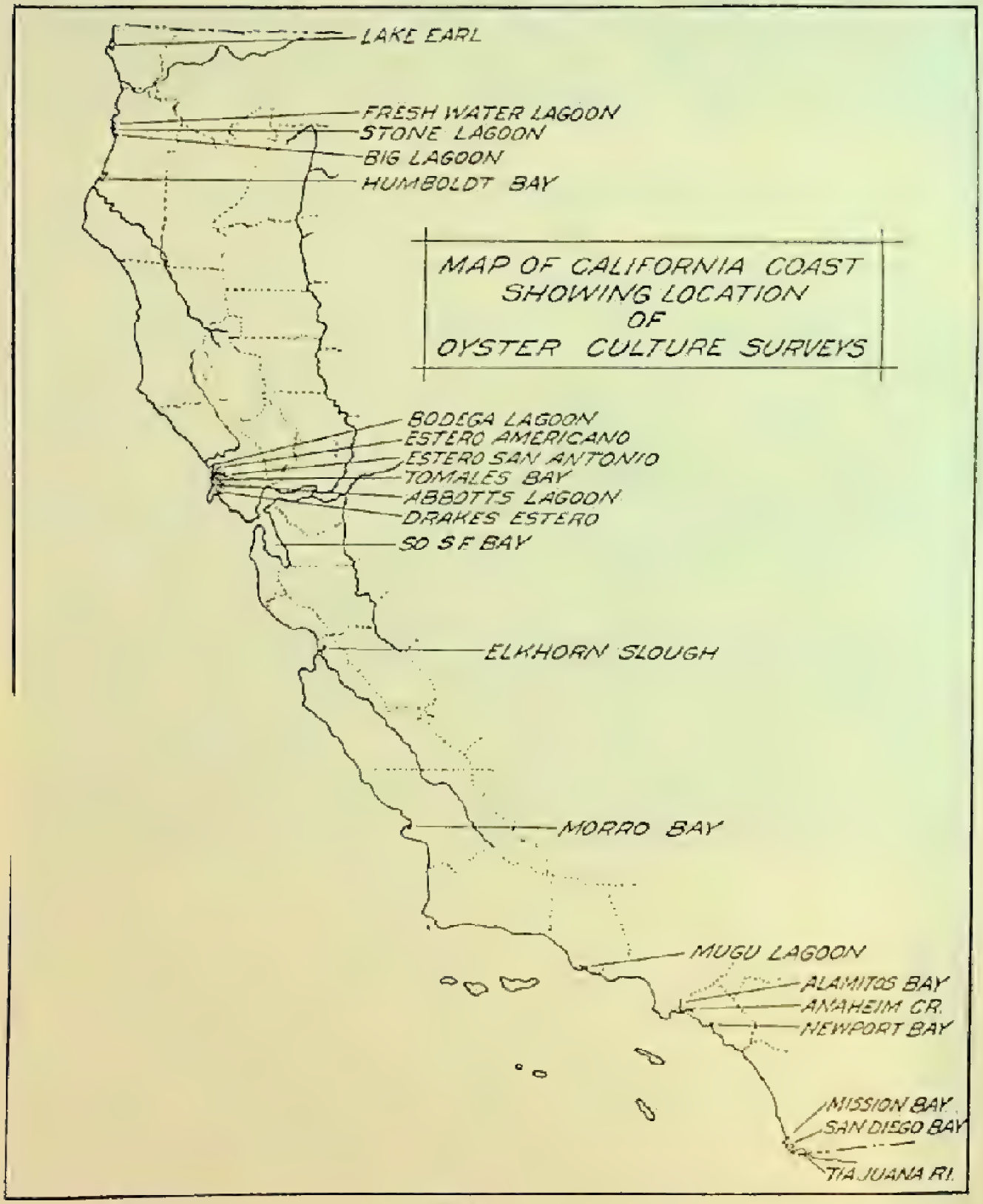


Fig. 26.

branching sloughs which drain a large tidal marsh covering about 3 square miles of territory. The bottom is muddy, hard in some places and soft in others, according to the strength of the current over the given area. Native oysters are plentiful in the channels. In places

where the tidal currents are swift the oysters develop a thick shell and have a fair quality of meat. Where the water is sluggish the shell is thin and the oysters too small to be marketable. An experimental plant of Japanese seed was made which did fairly well but the higher ocean temperature of this region will no doubt act adversely on the Japanese oysters as well as on the natives.

Newport Bay.

Newport Bay, about 30 miles south of San Pedro, has a wider and deeper entrance than most of the lagoons of the southern California coast. The lower end of the bay consists of two dredged channels, the north channel to the railroad bridge being 14 feet deep and the south channel to the town of Newport having a depth of 10 feet. There is a large arm of the bay extending inland from the new highway bridge which contains some natural oyster beds. Oysters are found on rocks, piles and every solid object that is available to the larvae. The bay will evidently produce seed in large quantities and any reasonable amount may be gathered annually and taken to other places if it is found profitable to grow it in different waters. There has been some activity in the transportation of native oysters from San Quentin Bay, Lower California, and transplanting them in Newport Bay, but as the oyster from Lower California is the same species as that already in Newport Bay, it would seem more desirable to work with the local ones.

Mission Bay.

Mission Bay contains native oysters in small quantities. As an oyster prospect it can not be used, however, as the State has appropriated it as part of its public playground program and its extensive clam flats bring many people who keep the bottom well turned over.

San Diego Bay.

San Diego Bay contains native oysters in small quantities everywhere. In common with San Francisco Bay, it receives large quantities of raw sewage from many of the towns which are built around it and it would probably be impossible to find any place in the bay clean enough to raise oysters which would pass the State Board of Health regulations.

Tia Juana River Estuary.

The Tia Juana River Estuary empties into the ocean about two miles north of the Mexican boundary. During the larger part of the time there is no discharge of fresh water and the estuary is subject to tide flow through a series of narrow channels which spread out fanlike from the mouth of the river. The bottom is fairly firm and carries a typical marine fauna. Native oysters are found here but they are very poor in quality and probably could not be marketed. Oil drilling has been started in the vicinity with consequent pollution problems. No oysters could be profitably grown here.

BIOLOGY AND CULTURE

Oysters can not be artifically reared on a commercial scale although their life history is well known. Oyster growing on any extensive scale must be carried on in the natural environment by manipulating the existing conditions to the best advantage.

The California native oyster is hermophroditic. Each individual contains both eggs and sperm but these are developed at different times so that the eggs of one oyster are fertilized by the sperm of another. The egg is fertilized in the mantle cavity and the resulting zygote, or embryo, is retained there until it has passed through several stages and has become a trochophore, at which stage it is a free-swimming organism able to take care of itself. The native oysters spawn in California from May until September, and there is a continuous throwing out of spawn during that period. The swimming larvae may be picked up with a plankton net during the time. After a period of development as a free-swimming organism the young larva selects a situation to its liking, usually an old oyster shell (though any fairly clean hard surface will do), and fastens its shell securely by the left side. This is called "setting" and it is the most critical stage with which the oyster grower has to deal. Although the swimming larvae may be present during the whole summer, they set in two or more successive waves, induced perhaps by an optimum combination of temperature, salinity and tides. This phenomenon is not thoroughly understood as yet.

The Japanese and eastern oysters are bisexual, that is, the sexes are separate. The eggs and sperm are thrown out into the water and there the eggs are fertilized and begin the life cycle. Unlike the natives, which spawn over a considerable period of time, the stimulation resulting from the discharge of one or more Japanese or eastern males seems to react on all the surrounding oysters in the bed and the spawning occurs at once and completely. The young of the Japanese and eastern oysters go through the same stages as the natives and set in the same manner.

Experiments at Elkhorn Slough for the last two seasons have consisted of manipulating natural conditions in an endeavor to obtain a set of Japanese oysters. A small dike was built and floored with abalone and oyster shell. The spot selected for the dike was the most favorable for temperature, salinity and current. Japanese oysters will spawn and set within a temperature range of 15° to 30° C. and a salinity range of 1.017–1.021. The temperature of the water was maintained within the required range but the salinity was a little high. However, the oysters spawned during both seasons and passed through the critical development stages to what is called the first umbo stage, when one of the valves begins to hump up. At this stage the larvae begin to take food for the first time and it was at this point during both the past seasons that they disappeared from the water. It would seem, therefore, in the light of our present knowledge, that the larval food required by the Japanese spat is wanting at Elkhorn Slough.

As previously stated, the setting time is the most critical period for the oyster grower. The concensus of opinion, from many experiments on the east coast of the United States, is that cultch, in the form of oyster, scallop or clam shells, or more recently cardboard

eggcrate fillers coated with cement, should be put into the water just before the setting time in order to have it as clean as possible. The main reason advanced for this procedure is that the cultch after being in the water for only a short time becomes coated with a film of slime and growths of algae, becoming therefore unsuitable for the setting oysters which can not find a clean spot on which to set.

The catching of spat has been recognized for centuries as the critical period in oyster culture. The Romans used twigs as spat collectors and, after collecting their seed, tied the twigs in bundles and hung them in the water from ropes. The Japanese have used bamboo for many years and more recently tarred rope. The French and Hollanders use a curved tile coated with a mixture of cement and sand which can be flaked off after the young oysters have set. From this latter method has been developed the present usage of the cardboard eggcrate fillers dipped in a mixture of sand and cement. The most usable of the cement formulas developed by the French for this type of collector are as follows:

(1) 1 pt. quicklime, 3 pts. fine sand.
(2) 1 pt. quicklime, 1 pt. fine gray mud.
(3) A light coating of quicklime and after drying a coat of hydraulic cement.

The mixtures should have the consistency of cream. The handling of tile would be too expensive in this country but, so far, the cardboard eggcrate fillers have worked very satisfactorily. By the time the young oysters are large enough to be out of the danger of being smothered on muddy bottoms the paper collectors have disintegrated and the oysters are automatically planted.

The first essential in growing oysters is a detailed and continuous record of temperatures and salinity and a knowledge of current sets and speeds. The swimming spat are evidently influenced by conditions which are sometimes imperceptible to us. They will set in large numbers in one part of a bay and not in another for reasons that are sometimes not at all clear. By experimenting, the best places in a bay can be determined and the spat collectors concentrated there. The spat also favor the under side of the cultch and set best where there is plenty of current. These points must be taken into account in placing spat collectors.

As has been mentioned, the spat set in several successive waves. These setting spells are of short duration, generally not exceeding 12 hours. The cultch should be in the water in plenty of time for the reception of the spat. It would seem a better procedure to have the cultch out several weeks in advance of a set than to miss a part or all of it by waiting until the spat had actually begun to drop. Inasmuch as experience has shown that the under side of any cultch catches the greater part of the set and the present practice is to arrange the cultch so that as much of the surface as possible faces downward, any accumulation of silt on the upper surfaces does not materially affect the set as a whole. The fact that the under side is seldom exposed to the sun, but remains in shadow, would retard the growth of most algae and if a good current is present cultch can remain in the water for some time before any of its ability to catch the swimming spat is lost.

ENEMIES

Oysters, in common with all other organisms, have natural enemies which tend to keep the population at a definite level. If these checks could be eliminated, all our inshore waters would soon be filled to the water level with oysters. However, a balance is maintained in a natural environment. When cultural methods are applied in order to increase the oyster population, the artificial conditions which react favorably

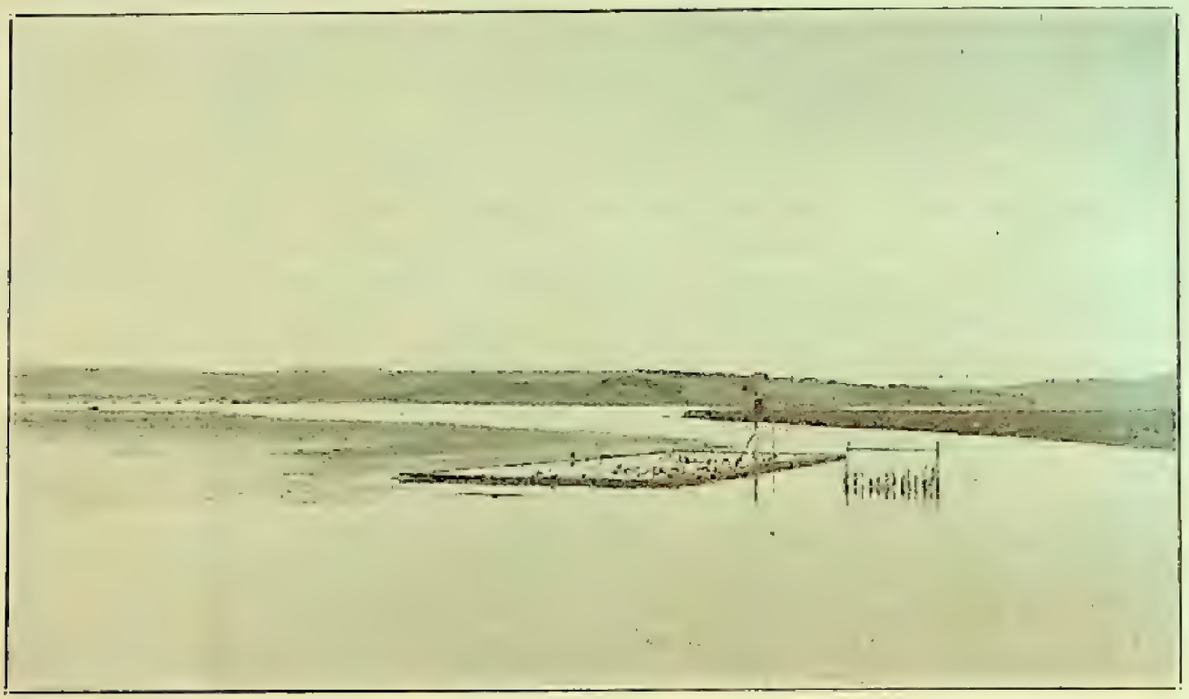


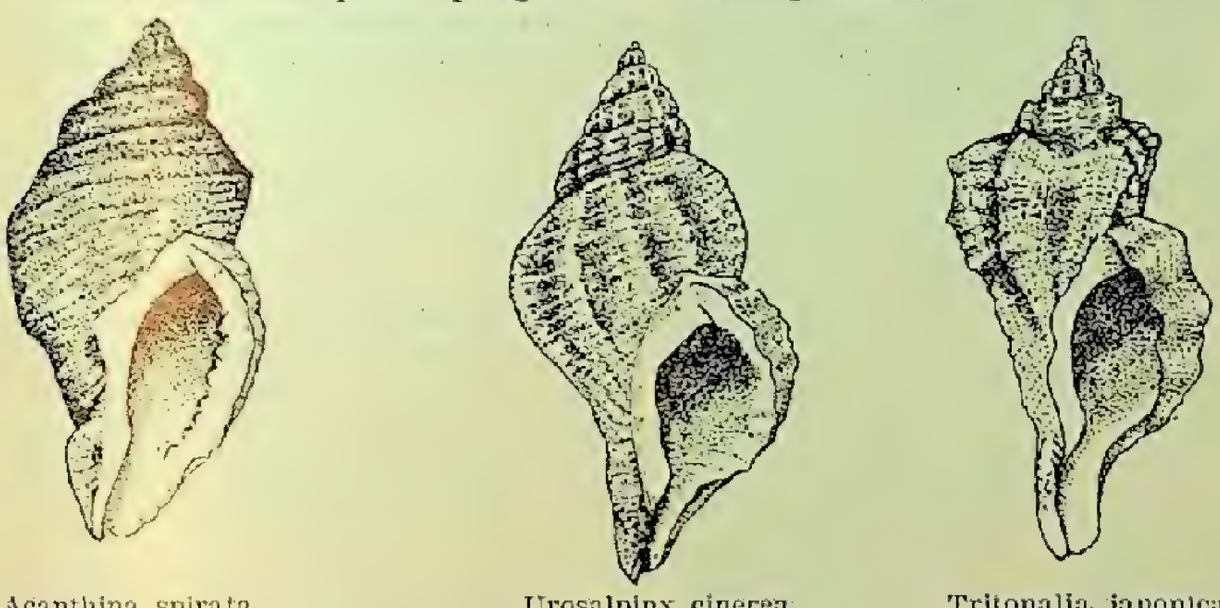
Fig. 27. Experimental dike, Elkhorn Slough. Strings of Japanese shells for catching spat in the channel. This dike caught a heavy set of natives. August 15, 1934.

for the oysters also react in the same manner on some of the oysters' enemies and these become a serious problem. Sometimes in moving oysters from one part of the world to another, the new environment is found to be much more favorable for oyster growth than the original situation, but the same conditions which make the new place ideal for the oysters make it also ideal for any enemies that may have been imported. For this reason all imported oysters should be rigidly inspected; they should be brought in only during certain times of the year and in some cases no importation should be allowed at all. California now has an inspection law by which all imported oysters must be inspected before being placed in any of the bays or inlets of the State. Before this law went into effect, several years ago, the importations of Japanese oysters and seed were regularly inspected through the cooperation of the seed importers. Some of the first shipments were well infested with various organisms. From 20 boxes of Japanese seed oysters received March 5, 1930, some 22 species of mollusks and crustaceans were obtained, while a small shipment received March 7, 1930 was badly infested with the Japanese drill. Both adults and egg cases of this gastropod were all through the shipment. It was condemned and since that time the Japanese seed has been inspected in Japan before shipment and is very clean.

The worst offenders among the oyster enemies on the Pacific Coast at present are all imported. They are the eastern oyster drill (*Urosalpinx cinerea*), the Japanese oyster drill (*Tritonalia japonica*) and the eastern slipper shell (*Crepidula fornicata*). The native drill (*Acanthina spirata*), having local checks of its own, is never very numerous and does little damage although it drills a few oysters. Another animal which is destructive to oysters is the sting ray (*Aetobatus californicus*). This fish sometimes destroys a great many oysters in a short time. Its depredations are checked by surrounding oyster beds with stake fences. The sting ray does not do very much damage to the Japanese oysters, especially if the oysters are growing in clusters. The rays seem unable to work effectively on a rough shell bottom.

A serious problem is created in some areas by the ghost shrimps. These animals, members of the family *Callianassidae,* burrow in the bottom and by pumping water through their burrows tend to keep the mud stirred up and make the bottom very soft. In some Puget Sound areas they cause trouble by driving their burrows under the dike walls, allowing the dikes to drain at low tide and necessitating in some places the building of double walled dikes. The two species which are the most numerous are *Eupogebia pugetensis* and *Callianassa californiensis.*

The oyster growers on the east coast are much troubled by starfish (*Asteriidae*), but so far these animals have caused little damage on our west coast, though they are present in considerable numbers. Another animal which sometimes causes damage, especially in natural and unworked beds, is the boring sponge (*Cliona sulphurea*). The sponge does not actively attack the oysters but it bores the shells and the oysters become poor and watery through wasting so much energy endeavoring to build shell to keep the sponge from breaking through.



Acanthina spirata Urosalpinx cinerea Tritonalia japonica

Fig. 28. The drills found in California bays—native, eastern and Japanese.

An enemy which so far has not troubled the California oysters is the flatworm. There are many species of these animals that are indigenous. In Florida and in New South Wales whole oyster beds have been destroyed by the depredations of these animals. A good many come with the Japanese seed oysters, but in only one case has any been found alive. In this case the shipment arrived in record time and

several of the living worms were collected. Although they proved to be young specimens which made identification impossible, Dr. Harold Heath, of Stanford University, to whom they were submitted, said that they were of the same type and possibly the same species which caused such havoc on the New South Wales beds. By holding this shipment of seed for several days and then washing it with fresh water just prior to planting the worms were effectively eliminated.

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CALIFORNIA FISH AND GAME

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Vol. 21 JANUARY, 1935 No. 1

CHANGES IN PERSONNEL

HERBERT C. DAVIS, APPOINTED EXECUTIVE OFFICER

Some important changes have occurred in official positions in the State Division of Fish and Game. While there are expressions of regret and sorrow at the separation from the Division of interested and capable men, there is among the employees a pronounced and friendly feeling of loyal willingness to cooperate with the newly appointed officials in any measures or policy which they may establish.

Resigning from the Division are Commissioner Earl B. Gilmore, who for three years has contributed valuable time and thought in the general effort to maintain and improve the condition and operations of the Division; Executive Officer John L. Farley, whose service extending over a period of six years, has won for him a recognized position among the best informed officials concerned with the conservation of fish and game; and Opie L. Warner, publicist, and Ralph Bandini, assistant publicist, who have been concerned with offering the public authentic information relating to the aims, efforts and accomplishments of the Division.



HERBERT C. DAVIS

Effective December 15, 1934, Herbert C. Davis was appointed as the new executive officer of the Division of Fish and Game. He has had a wide experience which should furnish exceptional qualifications for the post inasmuch as he is a recognized expert in agriculture, commercial problems, chemical and bacteriological research.

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He was born in Alameda County, in 1899. His early school career took place around the San Francisco Bay area, later he attended St. Matthews school at Burlingame, and this was followed by his graduation from the Hitchcock Military Academy, at San Rafael. He then took courses at the University of Nevada and the University of California, where he studied chemistry, bacteriology and agriculture.

Following this course of study, he entered the World War, being assigned to the Coast Artillery. In 1919, he engaged in ranching in Sacramento County, farming as high as a thousand acres at a time.

In 1925, Mr. Davis established commercial, chemical and bacteriological laboratories in Sacramento, and the Davis Laboratories which is the name of his concern, is still in existence.

During the last nine years, he spent a considerable portion of his time in the courts of the State and in the Federal Courts as an expert witness in many scientific lines. His hobbies are public speaking and amateur theatricals. In his public speaking career, he delved into the early '49 history of California.—*J. O. S.*

1934 LEGAL DEER KILL

The returns for the 1934 deer season appear in the statistical section of this issue. The legal kill of bucks during the year was 20,805. The tags made out by successful hunters last year amounted to 17,686. This shows an increase in the number of deer killed this year over last of 3119.

The kill by counties follows, showing the increase or decrease over 1933:

Alameda 204, increase 56; Alpine 102, decrease 35; Amador 76, increase 10; Butte 335, increase 130; Calaveras 148, increase 34; Colusa 168, decrease 52; Contra Costa 19, increase 10; Del Norte 32, increase 15; El Dorado 417, increase 49; Fresno 1359, increase 471; Glenn 260, increase 7; Humboldt 877, increase 35; Inyo 285, decrease 12; Kern 251, decrease 15; Kings 6, increase 1; Lake 419, decrease 62; Lassen 632, increase 81; Los Angeles 750, increase 178; Madera 310; increase 42; Marin 341, increase 40; Mariposa 160, increase 60; Mendocino 1185, decrease 49; Merced 60, increase 15; Modoc 1553, increase 558; Mono 103, decrease 22; Monterey 736, increase 105; Napa 288, increase 3; Nevada 183, increase 28; Orange 55, increase 19; Placer 175, decrease 21; Plumas 1128, increase 211; Riverside 307, decrease 47; Sacramento 1, decrease 1; San Benito 214, increase 42; San Bernardino 180, increase 27; San Diego 259, increase 86; San Joaquin 17, increase 3; San Luis Obispo 497, increase 61; San Mateo 133, increase 28; Santa Barbara 608, increase 61; Santa Clara 421, increase 28; Santa Cruz 108, same as last year; Shasta 630, increase 113; Sierra 179, increase 21; Siskiyou 1043, increase 220; Solano 20, increase 1; Sonoma 704, decrease 44; Stanislaus 39, increase 2; Tehama 866, increase 297; Trinity 464, increase 124; Tulare 836, increase 211; Tuolumne 218, increase 43; Ventura 398, decrease 10; Yolo 91, increase 3; Yuba 56, increase 25.

Modoc County, with 1553, takes the lead in number of deer killed, as well as the biggest increase over last year. This is remarkable in

view of the fact that Modoc has a one-buck limit and forked horns can not be legally killed.

Fresno with 1,359 tags is second, and the second in numerical increase, with 471.

Mendocino County, which for the last five years has led the rest of the State, is third in tags returned, and shows a decrease over last year of 49.

Other counties with increase this year are Tehama 297 tags, Siskiyou 220, Plumas and Tulare 211 each, Los Angeles 178, Butte 130, Trinity 124, Shasta 113 and Monterey 105.

The sale of deer tags is estimated at a little over 100,000. This means that one hunter out of five tag purchasers was successful in getting a deer. The average since 1927 is almost one out of six, so this year the venison seekers had better luck.

The check of tags also reveals that 2758 hunters got the limit of two bucks this year, a couple of hundred more than last year.

Los Angeles County, with 2136, furnished the most successful hunters. From Alameda County 825 hunters got their buck; Sonoma has 881 who brought home the venison; Fresno hunters to the number of 823 shot down their deer; Humboldt has 656 lucky marksmen. There were 599 Santa Clarans who got a buck each; 549 from Siskiyou and 585 from Monterey displayed unerring aim.—*O. L. Warner, November 22, 1934.*

FISH CULTURE EMPLOYEES' CONVENTION

The Bureau of Fish Culture held its first conventoin wherein the entire personnel of the Bureau was present, in San Francisco, on October 3, 4 and 5, 1934. In past years, it has been the custom to hold two conventions, one in the northern part of the State and the other in the southern part, each being attended by the hatchery men of the respective sections.

A varied program covering the many problems in fish cultural work was presented. Opportunity for questions and exchange of ideas was had, and it is hoped that the success of this convention will merit its becoming an annual affair.

Through the courtesy of the director of the Steinhart Aquarium, at Golden Gate Park, members of the Bureau were permitted to view the operation of this Aquarium, the night of October 3d.—*J. O. Snyder, December 7, 1934.*

BLACK BEARS RELEASED IN SOUTHERN CALIFORNIA

Early in July, 1933, President J. Dale Gentry expressed a desire to have black bear released in the Angeles and San Bernardino national forests provided that they could be secured at a nominal expense. Accordingly, a letter was written to C. G. Thomson, superintendent of Yosemite National Park, where fortunately there was an excess of bear on the Valley floor, and arrangements were made with the National Park Service to trap some of the bear.

There resulted a capture of 28 animals, however, one bear was lost through injuries which occurred during trapping and transporta-

tion. They were released as follows: 11 near Crystal Lake, Los Angeles County; 6 near Bear Lake and 10 in the Santa Ana Canyon, San Bernardino County. The plants were made during November, 1933, the last load arriving on the 27th.

Upon being released the bear quickly disappeared and are now seen only occasionally and in widely separated areas. One wandered into Chino Valley, and one in Yucaipa Valley. These were trapped and returned to the mountains. One strayed to the desert several miles east of Lancaster and was killed by a hunter using a Lueger pistol. Natural feed is scare in the high mountain areas in the south which probably accounts for the wide drift from the releasing points.

Their capture, transportation and release occasioned much comment in the local press and their introduction was generally approved. If they thrive, they will become a real attraction to the thousands of visitors who spend summers and week-ends in the mountain playgrounds. Their comical, clownish appearance and actions are a never ending source of amusement to youngsters and adults alike.—*A. E. Burghduff, December 11, 1933.*

A CORRECTION

In California Fish and Game, vol. 20, no. 3 (July, 1934), an error was made in the note, "Change in Form of Fishery Statistics."

The boundary for Region 60, Santa Barbara, should read, "includes the coast from Piedras Blancas to Point Dume"; instead of "includes the section from Point Dume to San Mateo Point" which latter is the boundary of Region 70, Los Angeles.—*N. B. Scofield, November 16, 1934.*

COMMERCIAL FISHERY NOTES

REPORTS OF THE CATCH BY TRAWLERS

The statistics of fish catch in this State are handled on punched cards so that the figures may be compiled by machine quickly and cheaply in any form desired. In addition to routine totals, a number of separate reports have been run on the machines to supply some special piece of information or to be used by the research staff in an investigation under way at the time. Special reports of the trawler catches have been run as an aid to our study of this fishery, and the following is one example of the many uses to which the punched card reports have been put. The quotation is from a letter dated November 23, 1934, by G. H. Clark of the California State Fisheries Laboratory:

"The trawler reports are being extremely useful, not only to me in the work, but to the trawler operators as well. All the operators receive each month a summary report of your reports XL (summary of catch by locality) and XLI (summary of catch by species), which we prepare for them. The secretary of the Central Pacific Wholesale Fish Dealers' Association plots the catches of the trawlers on one of our small fisheries charts, using colored pins to represent species, each pin on the chart accounting for 10,000 pounds of fish. A chart is kept for each month, and the arrangement shows at a glance where the various species of fish were taken and the amounts. The dealers are using these plotted charts to aid them in their trawler operations."—*W. L. Scofield, California State Fisheries Laboratory, November, 1934.*

CHANNEL ROCKFISH *(Sebastolobus alascanus)*

Within the past year or two *Sebastolobus alascanus,* formerly taken infrequently in southern California, has been landed in appreciable numbers with the catch of commercial fish. The fishermen call this fish channel cod, but because the term cod is ambiguous and misleading and because the fish is closely related to the rockfishes, it is here officially designated channel rockfish.

This species belongs to the rockfish family (Scorpaenidae) and superficially, closely resembles these fishes. It can be distinguished from the rockfishes (*Sebastodes*), however, by its greater number of dorsal spines, usually 16 instead of 13; the shape of the pectoral fin, the lower rays of which are prolonged, giving the fin a bilobed appearance; the exceptionally large head and slender body; and the conspicuous rows of spines above the eyes and across the cheeks. The color is bright rose-red.

Sebastolobus alascanus usually is taken in relatively deep water from 100 to 300 fathoms with an extreme range of 10 to 820 fathoms. It has been recorded from Bering Sea to southern California. A second species, *S. altivelis,* also occurs in this general distributional range, but as a rule at greater depths, 300 fathoms or over. As yet *S. altivelis* has not been observed in the commercial fisheries of southern California.

Channel rockfish are caught almost exclusively with sablefish and constitute an incidental catch in this fishery. Boats fishing for sablefish, *Anoplopoma fimbria,* use set lines similar to the gear used for rockfish but operated in deeper waters than when fishing for rockfish. Beginning with 1932 the fishery for sablefish expanded greatly in southern California, and this undoubtedly accounts for the appearance of channel rockfish in the commercial catch.

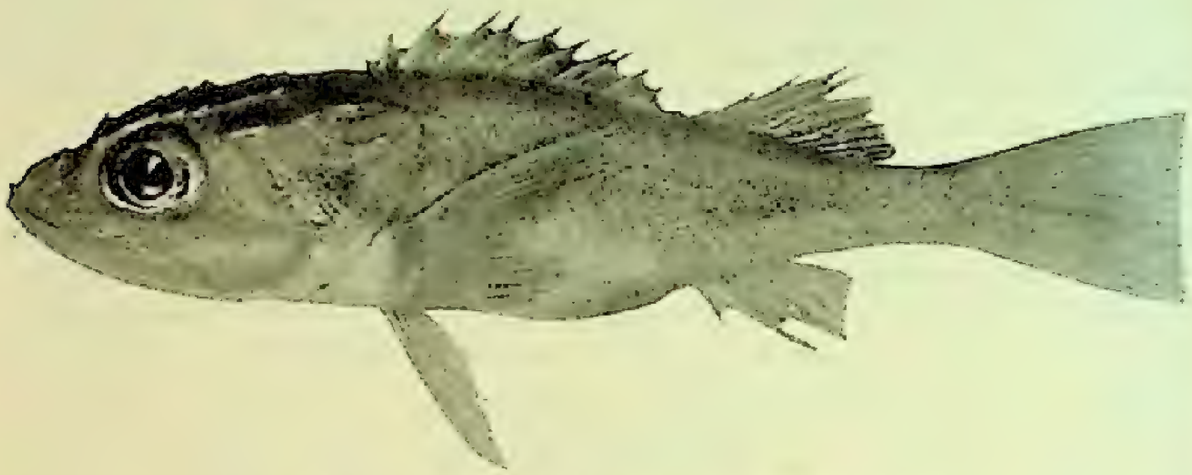


Fig. 29. Channel rockfish, *Sebastolobus alascanus.*

Only a portion of the dealers distinguish between channel rockfish and rockfish, consequently we have no complete record of the total poundage of *Sebastolobus* landed. The data available, however, indicate that the channel rockfish catch is equal to 5 or 10 per cent of the sablefish catch. Between 5000 and 10,000 pounds of channel rockfish were taken in southern California in 1932 and from 25,000 to 50,000 in 1933.—*Frances N. Clark, California State Fisheries Laboratory, September, 1934.*

SIZES OF BAY SMELT IN THE CALIFORNIA COMMERCIAL FISHERY

In 1933, a law was passed by the California State Legislature prohibiting commercial fishermen from catching either jack smelt (*Atherinopsis californiensis*) or bay smelt (*Atherinops affinis*) of less than 7½ inches in total length. This law has caused much discontent because fishermen claim that it practically eliminates bay smelt from the commercial catch. Almost all jack smelt taken commercially are larger than 7½ inches, so no objections are raised to the application of this law to the jack smelt. To determine the sizes of bay smelt caught by commercial fishermen, measurements were made of the catch in the San Francisco and San Pedro markets. The San Francisco measurements, 310 in all, were made between September 25, 1933, and February 15, 1934. The San Pedro measurements, totaling 260, were made from June 11 to October 22, 1934. The length frequencies resulting from these measurements are presented in figure 30. In both localities over 90 per cent of the bay smelt was less than 7½ inches in length. This substantiates the claims of the fishermen.

In the San Francisco region bay smelt are taken by the commercial fishermen in gill nets almost exclusively, whereas at San Pedro these fish are caught for the commercial markets in round haul nets. Bay

smelt along the Pacific coast consist of different subspecies peculiar to each locality, and the subspecies to the northward attain a larger size than to the south. For this reason presumably the San Francisco catch would consist of more large fish than at San Pedro. This evidently is not the case, perhaps because of the gill net fishery which selects only certain sized fish. But in spite of some size selection the majority of the bay smelt available to the fishermen at both San Francisco and San Pedro is less than 7½ inches in length.

According to Schultz,* two-thirds of the California bay smelt matures by the time the fish are 5 inches in length and all mature before they reach 6 inches. The greater part of the commercial catch, therefore, consists of adult fish and the majority of the population has apparently run out its life course before reaching a length of 7½ inches. A size limit of 7½ inches seems unnecessary, therefore, for a species attaining such a small size.

Furthermore, the total catch of jack and bay smelts in California is not large and probably places no great strain on the supply. Two-thirds to three-fourths of this catch consists of jack smelt. The size at maturity ** of jack smelt varies from 6½ to 10 inches, with about one-half mature at 7½ inches. If protection for jack smelt were needed, the size limit should be not less than 11 inches. The present limit does not exclude jack smelt from the catch, as very few fish taken by commercial fishermen are less than 7½ inches, and unless the complete elimination of the bay smelt catch is desired there seems no valid reason for this size limit.—*Frances N. Clark and G. H. Clark, California State Fisheries Laboratory, October, 1934.*

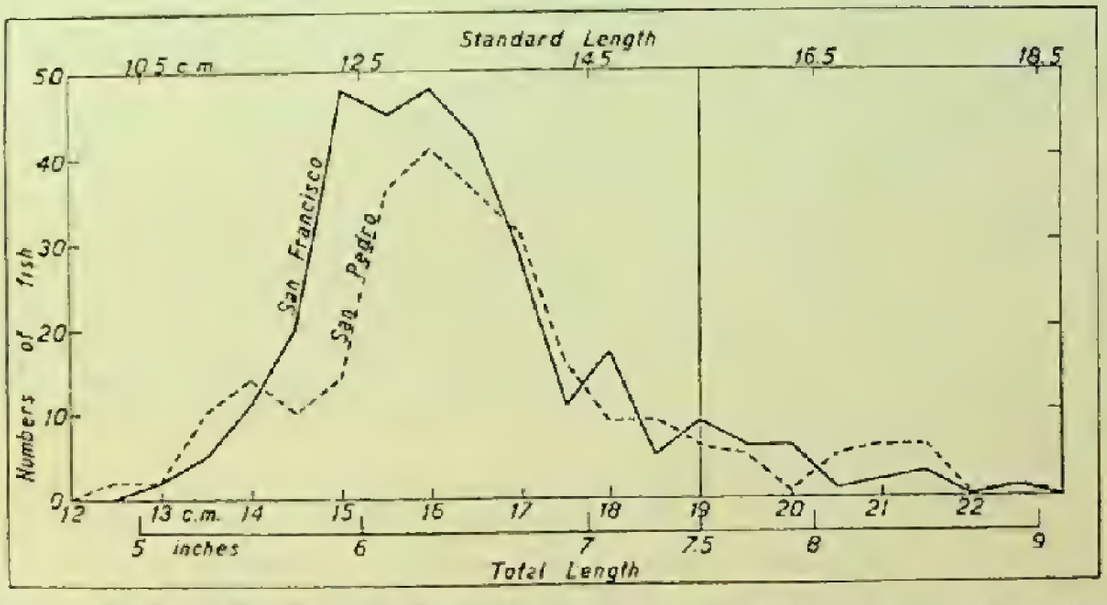


Fig. 30. Length frequency polygons showing sizes of bay smelt in the California commercial fishery.

* Schultz, Leonard P. The age and growth of *Atherinops affinis oregonia* Jordan and Snyder and of other subspecies of baysmelt along the Pacific coast of the United States. Washington Univ., Publ. Biol., vol. 2, no. 3, pp. 45–102, 1933.

** Clark, Frances N. The life history of the California jack smelt, *Atherinopsis californiensis*. Calif. Div. Fish Game, Fish Bull., no. 16, 22 pp., 1929.

MATURITY AND SPAWNING OF THE CALIFORNIA SARDINE

The development of sardine eggs before spawning, the time of spawning, and the location of the spawning and the nursery grounds are discussed in two fish bulletins recently issued by the Bureau of Commercial Fisheries of the Division of Fish and Game of California.

Fish Bulletin 42, by Frances N. Clark of the California State Fisheries Laboratory, points out that the most precocious sardines spawn for the first time when about 8 inches in total length, half the population is spawning at 8½ inches and all sardines are spawning by the time they are 10 inches long.

Sardine eggs start to develop within the ovary in December of each year. It takes two months or more for the eggs to ripen, and spawning begins in February and continues to August. The height of the spawning season is in April and May. This is true for sardines from San Francisco to San Diego. The percentages of sardines spawning in the neighborhood of San Pedro showed but little variation from season to season, whereas the percentages spawning in the Monterey area varied with the changes in temperature. In warm seasons, many more fish spawned within Monterey Bay than in cold seasons. Sardine spawning occurred at Monterey in April and May almost exclusively and spent fish were taken first each season in this region.

Detailed measurements of the rate of growth of the ovarian eggs in different localities, the percentages of ripe fish taken in each region, and the time and place of appearance of spent fish furnish further evidence to indicate that sardines are moving southward along the California coast during the winter months.

Fish Bulletin 41, by Eugene C. Scofield, working in cooperation with the Hydrobiological Survey of Hopkins Marine Station, defines the spawning grounds for the California sardine. Spawning occurs from San Francisco south to Cape San Lucas, Lower California, but the major spawning grounds lie in an area 200 miles in length and 100 miles in width between Point Conception and San Diego within 100 miles from shore. Eggs and larvae were found north of Point Conception only during warm seasons. The production of eggs and larvae in the area between Point Conception and San Diego was double that of all other spawning areas combined.

The eggs and larvae float within the upper 25 fathoms of water. At night the larvae congregate in the upper 5 fathoms. By the time the larvae metamorphose into young sardines (a period of about two months, during which they reach a total length of about 1¼ inches) they have drifted to the nursery grounds. These are located off the long, sandy beaches of southern California and the northern part of Lower California.

This demonstration that the major spawning area lies south of Point Conception and that the larval distribution is in the same region and to the southward, shows that the previously indicated southern movement of California sardines is a spawning movement occurring during the late fall and winter months preparatory to a spring spawning.

These two bulletins may be purchased for 15 cents each, from the Division of Fish and Game, 450 McAllister Street, San Francisco.—C. S. F. L., September, 1934.

STATEMENT OF INCOME

For the Period July 1, 1934, to September 30, 1934, of the Eighty-sixth Fiscal Year

REVENUE FOR THE FISH AND GAME PRESERVATION FUND

CURRENT YEAR:		
License sales—		
Angling licenses, 1934	$79,575 50	
Commercial Hunting Club licenses, 1934–35	200 00	
Commercial Hunting Club Operators' licenses, 1934–35	15 00	
Deer tags, 1934	22,983 00	
Fish Breeders' licenses, 1934	15 00	
Fish Importers' licenses, 1934	25 00	
Fish Packers' & Wholesale Shell Fish Dealers' licenses, 1934–35	700 00	
Game Breeders' licenses, 1934	47 50	
Hunting licenses, 1933–34	3,931 50	
Hunting licenses, 1934–35	65,669 78	
Kelp licenses, 1934	20 00	
Market Fishermen's licenses, 1934–35	18,700 00	
Trapping licenses, 1934–35	64 00	
Total license sales		$191,946 28
Other incomes—		
Court fines	$6,848 39	
Fish Packers' tax	30,521 93	
Fish Tag sales	618 03	
Game Tag sales	54 51	
Importers' contributions	5 00	
Interest on bank balances	1,497 28	
Kelp tax	44 81	
Miscellaneous sales	123 69	
Publication sales	169 65	
Total other income		39,883 29
Total current year		$231,829 57

STATEMENT OF EXPENDITURES

For the Period July 1, 1934, to September 30, 1934, of the Eighty-sixth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Administration:					
Executive	$2,089 98				$2,089 98
Clerical and office	1,380 00	$127 83	$48 84		1,556 67
Printing—general		23 05			23 05
Automobiles		63 08	171 14		234 22
Traveling			650 52		650 52
Postage			794 32		794 32
Telephone and telegraph			468 13		468 13
Freight, cartage and express			107 42		107 42
Rent			2,102 61		2,102 61
Accident and death claims			2,708 70		2,708 70
Accounting pro rata	1,125 00				1,125 00
Legal			92 50		92 50
Premiums on bonds			15 00		15 00
Total administration	$4,594 98	$213 96	$7,249 18		$12,058 12
Bureau education and research:					
Clerical and office	$480 00		$9 86		$489 86
Automobiles		$136 32	31 51		167 83
Traveling			370 60		370 60
Photography		11 84	29 40		41 24
Library	270 00		16 00	$7 50	293 50
Research	900 00	43 48	21 00		964 48
Publicity	712 50		9 01		721 51
Total bureau education and research	$2,362 50	$191 64	$487 38	$7 50	$3,049 02
Bureau patrol and law enforcement:					
Chief and assistants	$2,775 00				$2,775 00
Clerical and office	795 00	$3 38	$1 00		799 38
Automobiles		4,047 07	2,868 35	$1,550 46	8,465 88
Traveling			11,774 45		11,774 45
Postage			152 82		152 82
Telephone and Telegraph			369 85		369 85
Freight, cartage and express			1 19		1 19
Rent			155 02		155 02
Captains and wardens	46,480 00	58 39	60 87		46,599 26
Launches		288 47	147 29	118 37	554 13
Fish planting	1,155 00	326 57	26 00	12 19	1,519 76
Premiums on bonds			232 50		232 50
Cooks	375 00				375 00
Commercial fisheries patrol:					
Chief	600 00				600 00
Captains and wardens	3,430 00	2 08	2 00		3,434 08
Launches	2,955 00	703 10	199 73	145 02	4,002 85
Fish cannery inspectors—seasonal	1,099 37				1,099 37
Traveling			1,259 85		1,259 85
Rent			189 00		189 00
Automobiles		74 19	86 19		160 38
Total bureau patrol and law enforcement	$59,754 37	$5,503 25	$17,526 11	$1,826 04	$84,609 77
Bureau commercial fisheries:					
Chief and assistants	$3,405 00				$3,405 00
Clerical and office	2,400 00	$8 86	$5 17		2,414 03
Automobiles		100 97	64 33		165 30
Traveling			1,304 83		1,304 83
Telephone and telegraph			95 86		95 86
Freight, cartage and express			18 76		18 76
Rent			33 92		33 92
Heat, light, water and power			57 81		57 81
Research	570 00	8 18			578 18
Laboratory	5,760 00	75 72	124 51	$3 12	5,963 38
Statistics		21 61	509 00		530 61
Total bureau commercial fisheries	$12,135 00	$215 34	$2,214 22	$3 12	$14,567 68

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1934 to September 30, 1934, of the Eighty-sixth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Bureau fish culture:					
Chief and assistants	$1,815 00				$1,815 00
Clerical and office	1,260 00	$8 97			1,268 97
Automobiles		1,665 95	$562 87	$9 43	2,238 25
Traveling			2,131 76		2,131 76
Postage			53 05		53 05
Telephone and telegraph			246 42		246 42
Freight, cartage and express			148 61		148 61
Rent			313 00		313 00
Heat, light and power			376 49		376 49
Hatcheries	26,630 40	15,579 26	141 37	178 90	42,529 93
Fish cars	$85 00	156 98	537 01		1,579 89
Blue printing			21 77		21 77
Cooperative research	30 00	204 21	257 18	162 43	653 82
Temporary help	189 00				189 00
Fish hatchery assistants—seasonal	8,178 39				8,178 39
Hydraulic engineering	600 00	6 25	309 23		915 48
Special field	1,834 98				1,834 98
Fish rescue:					
Miscellaneous supplies		25 60			25 60
Heavy truck mileage			236 80		236 80
Travel			378 22		378 22
Motorized equipment		2 77		551 25	551 02
Chief and assistants	752 00		235 53		937 53
Total bureau fish culture	$42,174 77	$17,649 99	$5,950 21	$902 01	$66,676 98
Bureau game propagation:					
Chief and assistant	$1,365 00				$1,365 00
Clerical and office	210 00				210 00
Automobiles		$166 01	$46 78		212 79
Traveling			720 10		720 10
Postage			6 04		6 04
Telephone and telegraph			19 98		19 98
Freight, cartage and express			1 19		1 19
Heat, light, water and power			1,007 03		1,007 03
Maintenance	2,901 00	2,200 92	61 62	$4 55	5,168 09
Temporary help	33 55				33 55
Quail trapping and expansion of quail	1,155 00	213 38	551 59	10 55	1,930 52
Refuge maintenance	423 00				423 00
Total bureau game propagation	$0,087 55	$2,580 31	$2,423 33	$15 10	$11,105 29
Bureau game refuges:					
Chief and assistants	$2,124 99				$2,124 99
Clerical and office	480 00	$11 83			491 83
Automobiles		68 82	$21 27		90 09
Traveling			1,064 73		1,064 73
Blue printing			4 18		4 18
Lion Hunters	1,338 00				1,338 00
Refuge posting	225 00				225 00
Predatory animal control			1,110 00		1,110 00
Refuge maintenance	2,040 00	622 62	196 99		2,859 61
Predatory animal hunters and trappers seasonal	1,500 00				1,500 00
Temporary help—seasonal	1,053 50				1,053 50
Total bureau game refuge	$8,761 49	$703 27	$2,397 17		$11,861 93
Bureau licenses:					
Clerical and office	$3,285 00	$52 80	$4 75	$6 66	$3,349 21
Printing—licenses and applications		27 29			27 29
Traveling			69 25		69 25
Postage			310 90		310 90
Freight, cartage and express			50 77		50 77
Premiums on bonds			907 50		907 50
Total bureau licenses	$3,285 00	$80 09	$1,343 17	$6 66	$4,714 92
Total 86th fiscal year expense paid from support appropriations	$139,155 66	$27,137 85	$39,590 77	$2,760 43	$208,644 71

STATEMENT OF EXPENDITURES—Continued

For the Period July 1, 1934, to September 30, 1934, of the Eighty-sixth Fiscal Year

Function	Salaries and wages	Materials and supplies	Service and expense	Property and equipment	Total
Prior year expense for support 85th fiscal year					$13,073 94
Total 85th and 86th fiscal year expense paid from support appropriations					$221,718 65
Special items:					
86th fiscal year:					
License commissions			$8,892 25		$8,892 25
85th fiscal year:					
License commissions					305 15
Total special items					$9,197 40
Permanent improvements:					
Construction, improvements and equipment:					
86th fiscal year	$2,015 00	$1,791 28	$518 20	$1,357 31	$6,581 79
Bureau of commercial fisheries, Chap. 825-33					
Fresh fish marketing:					
Chief and assistants	$1,477 50				$1,477 50
Clerical and office	330 00				330 00
Printing		$203 21			203 21
Traveling			$354 12		354 12
Postage			65 00		65 00
Telephone and telegraph			35		35
Freight, cartage and express			121 08		121 08
Rent			7 47		7 47
Exhibits		142 06	1,712 12		1,854 18
Temporary help	45 00				45 00
Total bureau of commercial fisheries, Chap. 825-33 fresh fish marketing	$1,852 50	$345 27	$2,260 14		$4,457 91
Total from current biennium					$241,955 75
Prior Biennium:					
84th fiscal year:					
Support					$7 75
Grand total proprietary group					$241,963 50

EIGHT-YEAR RECORD OF DEER KILL IN CALIFORNIA

COUNTY	1927				1928				1929				1930				1931				1932			
	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total
Alameda	171	42	7	220	198	54	11	263	205	64	6	275	161	74	17	252	192	48	8	248	125	32	7	164
Alpine	14	21	32	67	20	23	23	66	24	32	33	89	54	27	43	124	44	38	47	129	64	55	62	181
Amador	19	18	22	59	28	31	19	78	32	27	28	87	40	26	35	101	39	32	33	104	25	28	16	69
Butte	74	68	86	228	80	71	61	212	82	70	82	234	113	100	101	314	152	172	170	494	100	94	93	287
Calaveras	50	47	52	149	77	65	49	191	61	58	56	175	118	86	79	283	81	84	62	227	63	51	34	148
Colusa	161	76	26	263	162	84	26	272	184	85	28	297	220	95	28	343	189	85	30	304	125	61	12	198
Contra Costa	4	1		5	5	1		6	11	2	1	14	5	1		6	7	4		11	6	2		8
Del Norte	16	12	14	42	18	10	20	48	27	13	15	55	8	19	13	40	11	12	15	38	6	6	1	13
El Dorado	183	173	179	535	176	183	189	548	215	21	180	597	262	227	196	685	260	209	230	699	166	162	134	462
Fresno	215	170	207	592	292	230	241	763	283	232	249	764	325	285	283	893	358	288	306	952	355	279	248	882
Glenn	284	242	97	623	250	198	114	592	306	210	70	586	301	224	76	601	229	148	53	430	209	103	36	348
Humboldt	389	258	174	821	336	200	151	777	254	249	156	659	393	319	205	917	525	351	193	1,069	378	273	156	807
Imperial	1			1	2		2	4	2	1	1	4			1	1					1		3	4
Inyo	74	48	51	173	89	76	74	239	96	81	76	253	88	76	87	251	87	64	60	211	71	57	52	180
Kern	83	72	63	218	129	82	84	295	135	103	59	297	130	101	93	324	160	121	73	354	86	62	48	196
Kings		3		3	1		2	3	2	1		3	9	1	2	12	2	4	4	10	4	5	4	13
Lake	599	220	73	901	695	267	76	1,038	583	194	64	841	585	227	73	885	501	172	53	726	332	137	55	524
Lassen	20	86	190	296	26	146	221	393	35	166	310	511	35	186	364	585	20	215	366	607	23	192	293	508
Los Angeles	279	92	54	425	256	70	43	369	470	150	71	691	437	144	56	637	678	180	91	949	598	159	62	819
Madera	96	77	87	260	126	84	90	300	122	91	100	313	148	124	107	379	186	133	123	442	117	89	110	316
Marin	297	58	12	367	362	68	14	444	337	48	9	394	347	46	10	403	385	54	10	449	323	46	7	376
Mariposa	32	31	32	95	50	47	37	134	53	52	39	144	80	72	83	235	87	57	46	190	50	43	41	134
Mendocino	853	426	196	1,475	791	477	200	1,468	728	422	205	1,355	822	456	205	1,483	1,014	496	196	1,706	710	384	179	1,273
Merced	41	21	5	67	45	16	7	68	20	15	4	48	45	17	6	68	42	15	3	60	26	13	6	45
Modoc		138	372	510		269	460	729		300	535	835		375	754	1,129		571	915	1,486		345	571	916
Mono	14	7	15	36	12	11	32	55	32	20	24	76	19	25	29	73	35	30	45	110	29	36	29	94
Monterey	541	161	55	757	536	217	77	830	502	173	59	734	577	211	76	864	635	187	78	900	342	100	42	484
Napa	242	155	45	442	327	179	63	569	332	149	42	523	337	142	57	536	333	114	41	488	184	89	31	304
Nevada	38	48	39	125	51	44	45	140	62	47	60	169	93	69	74	236	84	68	77	229	53	38	53	144
Orange	24	17	15	56	36	22	11	69	50	22	9	81	49	27	14	90	73	24	17	114	51	25	11	87
Placer	121	105	115	341	125	126	95	346	112	124	99	335	126	100	105	340	139	118	104	361	104	93	74	271
Plumas	177	109	205	551	177	192	217	586	233	194	268	695	270	196	289	764	337	280	351	968	275	257	297	829
Riverside	170	82	71	323	120	76	53	249	216	93	95	404	337	163	120	629	357	189	117	663	250	135	73	488
Sacramento					1		1	2						1	1	2	3		1	4	1		1	2
San Benito	150	54	13	217	210	90	20	320	180	67	22	269	197	89	27	313	205	54	16	275	106	29	17	152
San Bernardino	32	21	21	74	57	34	31	122	66	29	25	120	80	50	58	188	111	63	63	237	73	45	69	187
San Diego	95	38	36	169	120	76	36	232	114	66	53	233	141	65	44	250	175	98	61	334	142	76	45	263
San Francisco																								
San Joaquin	13	8		21	10	4		14	18	4		22	13	7	3	22	17	5	2	24	10	2	3	15
San Luis Obispo	251	103	40	394	200	112	48	450	255	140	60	455	353	126	89	568	347	147	58	552	226	93	58	377
San Mateo	61	13	3	77	83	4	2	89	78	22	2	102	81	14	5	100	88	10	5	103	63	19	3	785
Santa Barbara	424	154	91	669	526	204	121	851	445	164	108	717	471	204	102	777	506	180	69	755	345	126	61	532
Santa Clara	243	119	35	397	371	131	31	536	403	131	43	577	461	138	51	650	515	136	46	697	322	76	17	415
Santa Cruz	69	6	3	78	81	7	4	92	84	16	2	102	101	12	2	115	107	15	5	127	67	12	6	85
Shasta	171	240	201	612	175	230	198	603	190	267	245	702	203	237	215	655	222	281	270	773	149	176	202	527
Sierra	27	27	47	101	26	30	46	102	44	42	46	132	42	38	57	137	65	47	78	190	45	46	60	151
Siskiyou	424	491	750	1,665	450	522	682	1,654	218	366	627	1,211	270	478	624	1,372	297	517	702	1,516	149	300	447	896
Solano	22	16	7	45	30	15	7	52	31	20	3	54	41	13	4	58	34	9	2	45	17	13	1	31
Sonoma	519	188	44	751	506	194	53	753	469	216	47	732	532	263	70	865	587	251	65	903	478	180	51	709
Stanislaus	53	26	12	91	69	28	18	115	77	33	9	119	66	36	9	111	61	28	5	94	25	8	4	37
Sutter			1	1	2	1		3	1	1		2		1		1		1		1				
Tehama	286	288	225	799	280	329	237	846	284	262	212	758	343	247	255	845	263	271	181	715	208	173	106	487
Trinity	299	339	283	921	295	310	195	800	234	277	240	751	249	321	190	760	309	311	221	841	130	167	121	418
Tulare	341	200	203	744	484	250	205	939	361	257	189	807	418	319	228	965	400	254	236	890	292	231	202	725
Tuolumne	64	72	77	213	74	88	51	213	70	74	68	212	100	95	85	280	116	120	93	329	69	68	78	215
Ventura	164	74	36	274	226	99	37	362	233	75	38	346	208	74	26	308	256	99	35	390	210	66	41	317
Yolo	55	39	21	115	97	46	26	169	100	49	27	176	130	61	23	214	121	57	13	191	70	53	15	135
Yuba	24	19	10	53	22	21	9	52	23	14	18	55	43	33	17	93	34	28	29	91	14	9	11	34
Totals	9,069	5,688	4,750	19,507	10,113	6,537	4,865	21,515	9,823	6,282	5,117	21,222	11,085	7,172	5,875	24,132	12,087	7,545	6,173	25,805	8,492	5,429	4,459	18,380
Deer Tag License Sales	110,760				105,638				115,472				123,999				129,005				96,702			

EIGHT-YEAR RECORD OF DEER KILL IN CALIFORNIA

1929				1930				1931				1932				1933				1934			
2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total	2-point	3-point	4-point and over	Total
205	64	6	275	161	74	17	252	192	48	8	248	125	32	7	164	111	32	5	148	157	42	5	204
24	32	33	89	54	27	43	124	44	38	47	129	64	65	62	191	30	51	56	137	37	31	34	102
32	27	28	87	40	26	35	101	39	32	33	104	25	28	16	69	28	21	17	66	24	27	25	76
82	70	82	234	113	100	101	314	152	172	170	494	100	94	93	287	72	60	64	205	80	85	70	235
61	58	56	175	118	86	79	283	81	84	62	227	63	51	34	148	40	31	43	114	64	50	34	148
184	85	28	297	220	95	28	343	189	85	30	304	125	61	12	198	131	61	28	220	100	49	19	168
11	2	1	14	5	1	-------	6	7	4	-------	11	6	2	-------	8	5	3	1	9	13	6	0	19
27	13	15	55	8	19	13	40	11	12	15	38	6	6	1	13	10	4	3	17	14	0	0	32
215	21	180	597	262	227	196	685	260	209	230	699	166	162	134	462	114	123	131	368	138	133	146	417
283	232	249	764	325	285	283	893	358	288	306	952	355	279	248	882	335	303	250	888	646	387	326	1,359
306	210	70	586	301	221	78	601	229	148	53	430	209	103	36	348	127	95	31	253	122	112	26	260
284	249	156	689	393	319	205	917	525	351	193	1,069	378	273	156	807	391	297	154	842	371	321	185	877
2	1	1	4	-------	-------	1	1	-------	-------	-------	-------	1	-------	3	4	1	1	3	5	0	0	0	0
96	81	76	253	88	76	87	251	87	64	60	211	71	57	52	180	135	92	70	297	144	65	76	285
135	103	59	297	130	101	93	324	160	121	73	354	86	62	48	196	107	83	76	266	117	83	51	251
2	1	-------	3	9	1	2	12	2	4	4	10	4	5	4	13	3	2	-------	5	2	4	0	6
583	194	64	841	585	227	73	885	501	172	53	726	332	137	55	524	322	114	45	481	279	115	25	419
35	166	310	511	35	186	364	585	26	215	366	607	23	192	293	508	30	218	303	551	42	248	342	632
470	150	71	691	437	144	56	637	678	180	91	949	598	159	62	819	426	114	32	572	565	132	53	750
122	91	100	313	148	124	107	379	186	133	123	442	117	89	110	316	100	82	86	268	120	69	112	310
337	48	9	394	347	46	10	403	385	54	10	449	323	46	7	376	258	38	5	301	297	38	6	341
53	53	39	141	80	72	83	235	87	57	46	190	50	43	41	134	35	35	30	100	54	55	51	160
728	422	205	1,355	822	456	205	1,483	1,014	496	196	1,706	710	384	179	1,273	716	372	146	1,234	696	376	113	1,185
29	15	4	48	45	17	6	68	42	15	3	60	26	13	6	45	33	9	3	45	37	18	5	60
-------	300	535	535	-------	375	754	1,129	-------	571	915	1,486	-------	345	571	916	-------	300	565	955	0	597	956	1,553
32	20	24	76	19	25	20	73	35	30	45	110	29	36	29	94	55	31	39	125	46	25	32	103
502	173	59	734	577	211	76	864	635	187	78	900	342	100	42	484	423	150	58	631	472	179	85	736
332	149	42	523	337	142	57	536	333	114	41	488	184	89	31	304	203	55	27	285	178	95	15	288
62	47	60	169	93	69	74	236	84	68	77	229	53	38	53	144	49	50	55	154	66	55	61	182
50	22	9	81	49	27	14	90	73	24	17	114	51	25	11	87	25	6	5	36	20	11	15	55
112	124	99	335	126	109	105	340	139	118	104	361	101	93	74	271	61	71	64	196	64	66	45	175
233	194	268	695	279	196	289	764	337	280	351	968	275	257	297	829	304	305	308	917	422	310	396	1,128
216	93	95	404	337	163	129	629	357	189	117	663	280	135	73	488	206	95	53	354	220	60	27	307
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180	67	22	269	197	89	27	313	205	54	16	275	106	29	17	152	109	47	16	172	142	60	12	214
66	29	25	120	80	50	58	188	111	63	63	237	73	45	69	187	77	38	38	153	94	59	27	180
114	66	53	233	141	65	44	250	175	98	61	334	142	76	45	263	93	51	29	173	147	82	30	259
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18	4	-------	22	12	7	3	22	17	5	2	24	10	2	3	15	9	4	1	14	11	4	2	17
255	140	60	455	353	126	89	568	347	147	58	552	226	93	58	377	271	121	44	436	300	112	85	497
78	22	2	102	81	14	5	100	88	10	5	103	63	19	3	785	92	12	1	105	109	22	2	133
445	164	108	717	471	204	102	777	506	180	69	755	345	126	61	532	364	129	64	547	351	167	90	608
403	131	43	577	461	138	51	650	515	136	46	697	322	76	17	415	283	92	18	393	316	83	22	421
84	16	2	102	101	12	2	115	107	15	5	127	67	12	6	85	96	10	2	108	82	17	9	108
190	287	245	702	203	237	215	655	222	281	270	773	149	176	202	527	145	199	173	517	152	233	245	630
44	42	46	132	42	38	57	137	65	47	78	190	45	46	60	151	51	39	68	158	63	42	74	179
218	366	627	1,211	270	478	624	1,372	297	517	702	1,516	149	300	447	896	150	288	385	823	194	347	502	1,043
31	20	3	54	41	13	4	58	34	9	2	45	17	13	1	31	14	4	1	19	12	5	3	20
460	216	47	732	532	263	70	865	587	251	65	903	478	180	51	709	533	173	42	748	471	181	52	704
77	33	9	119	66	36	9	111	61	28	5	94	25	8	4	37	27	6	4	37	26	11	2	39
1	1	-------	2	-------	1	-------	1	-------	1	-------	1	-------	-------	-------	-------	-------	-------	-------	-------	0	0	0	0
284	202	212	758	343	247	255	845	263	271	181	715	208	173	106	487	231	108	140	569	328	318	220	866
234	277	240	751	249	321	190	760	309	311	221	841	130	167	121	418	102	140	98	340	109	214	141	464
361	257	189	807	418	319	228	965	400	254	236	890	292	231	202	725	274	201	150	625	429	216	191	836
70	74	68	212	100	95	85	280	116	120	93	329	69	68	78	215	48	62	65	175	61	78	79	218
233	75	38	346	208	74	26	308	256	99	35	390	210	66	41	317	241	117	50	408	218	114	66	398
100	49	27	176	130	61	23	214	121	57	13	191	70	53	15	138	51	22	15	88	51	29	11	91
23	14	18	55	43	33	17	93	34	28	29	91	14	9	11	34	11	16	4	31	23	19	14	56
9,823	6,282	5,117	21,222	11,085	7,172	5,875	24,132	12,087	7,545	6,173	25,805	8,492	5,429	4,459	18,380	8,150	5,372	4,164	17,686	9,314	6,267	5,224	20,805
115,472				123,999				129,005				96,702				95,776							

HUNTERS KILLING TWO DEER, 1934

County of residence of hunter	
Alameda	120
Alpine	2
Amador	7
Butte	48
Calaveras	8
Colusa	18
Contra Costa	27
Del Norte	8
El Dorado	20
Fresno	111
Glenn	20
Humboldt	123
Imperial	3
Inyo	23
Kern	72
Kings	9
Lake	23
Lassen	23
Los Angeles	301
Madera	16
Marin	37
Mariposa	8
Mendocino	57
Merced	15
Modoc	3
Mono	2
Monterey	82
Napa	28
Nevada	9
Orange	35
Placer	15
Plumas	53
Riverside	22
Sacramento	53
San Benito	29
San Bernardino	24
San Diego	23
San Francisco	106
San Joaquin	29
San Luis Obispo	70
San Mateo	32
Santa Barbara	85
Santa Clara	68
Santa Cruz	29
Shasta	52
Sierra	10
Siskiyou	89
Solano	28
Sonoma	119
Stanislaus	29
Sutter	22
Tehama	37
Trinity	25
Tulare	66
Tuolumne	10
Ventura	39
Yolo	22
Yuba	6
State of Nevada	3
State of Oregon	5
Total number of hunters getting the limit	2,458

SEIZURES OF FISH AND GAME

July, August, September, 1934

Fish—	
Abalones	234
Bass, striped, pounds	160
Bass, striped	144
Clams	2,831
Crabs	209
Cockles, pounds	420
Crappie	317
Lobster, pounds	772
Spotfin croaker	1
Trout	733
Trout, pounds	197
Yellowfin, pounds	23,155
Yellowtail, pounds	1,133
Nets, seines	3
Lobster traps	70
Game—	
Deer	57
Deer hides	2
Deer meat, pounds	282
Ducks, geese	97
Doves	679
Frogs	33
Nongame birds	7
Pheasants	10
Quail	30
Rabbits	16
Guns	5

GAME CASES

July, August, September, 1934

Offense	*Number arrests*	*Fines imposed*	*Jail sentences (days)*
Bear; closed season	1	----------	---
Deer; closed season; killing does, fawns, spike bucks; failure to tag	130	$4,513 00	378½
Ducks; geese; closed season	10	127 50	---
Doves; closed season	33	1,484 00	200
Hunting without license	53	895 00	70
Hunting in game refuge	24	350 00	10
Nongame birds; killing of	5	125 00	---
Night hunting	14	255 00	90
Pheasants; closed season	11	660 00	---
Pigeon; closed season	1	----------	---
Quail; closed season	18	800 00	75
Rabbits; closed season	7	100 00	---
Shorebirds; killing of	1	----------	---
Spotlight hunting	14	275 00	---
Shooting from highway	18	260 00	---
	340	$9,844 50	823½

FISH CASES

July, August, September, 1934

Offense	*Number arrests*	*Fines imposed*	*Jail sentences (days)*
Abalones; small	10	$200 00	---
Angling without license	43	610 00	60
Bass—			
Striped; small; overlimit	28	445 00	360
Black; small	3	10 00	---
Cockles; small	1	50 00	---
Clams; overlimit; small	66	1,032 50	25
Crabs; female	2	10 00	---
Crappie; overlimit	8	165 00	5
Commercial fishing, no license	47	340 00	---
Lobsters; closed season	10	60 00	75
Night fishing	20	255 00	---
Pollution of streams	1	---	---
Seines and nets, illegal use of	18	860 00	---
Trout; overlimit	15	277 00	---
Illegal fishing apparatus	1	25 00	---
Yellowtail; closed season	1	10 00	---
Yellowfin; small	2	75 00	---
Miscellaneous fish cases	13	75 00	---
	289	$4,499 50	525

CALIFORNIA FRESH FISH LANDINGS* FOR JULY, AUGUST AND SEPTEMBER, 1934

Compiled by Division of Fish and Game, Bureau of Commercial Fisheries

Species of fish	Region 10, Del Norte	Region 20, Eureka	Region 30, Sacramento	Region 40, San Francisco	Region 50, Monterey	Region 60, Santa Barbara	Region 70, Los Angeles	Region 80, San Diego	Total pounds
Anchovy				28,535	25,005		5,566		59,106
Barracuda					6	7,407	885,190	131,247	1,026,850
Cabezone					1,410	5			1,415
Cabrilla							82,050	10,327	92,377
Carp			9,169	1,563					10,732
Catfish			37,057						37,057
Corbina, Mexican							75		75
Cultus, Pacific	5,015	46,600		236,616	17,161	88	105		305,075
Flounder, Starry				256,367	4,080				260,447
Flying Fish							9,855		9,855
Grouper							12,966	359	13,325
Hake				5,580			26		5,606
Halibut, California				1,701	13,755	51,518	54,269	99,560	220,803
Halibut, Northern	1,646	315,160		119,660					436,466
Hardhead			50	106					156
Kingfish				2,763	53,875	40	66,293	1,396	124,372
Mackerel, Horse					59,056		214,000		273,056
Mackerel, Pacific				15	3,570,985	12,677	48,964,764	4,773,869	57,322,310
Mackerel, Spanish								822	822
Mullet							1,449	8,933	10,382
Perch		156		22,388	8,266	417	11,061	30	42,318
Pompano, California					63		726		789
Rock Bass						1,555	68,654	39,768	109,977
Rockfish	1,477	29,238		204,075	417,241	55,428	163,051	83,155	953,665
Sablefish	302	271,883		55,808	89,930	1,029	64,640	208	483,800
Salmon	58,584	1,714,714	232,011	764,975	45,390				2,816,274
Sand Dab				208,130	7,114		1,638		216,891
Sardine			20,186,564	8,277,175	119,255,582	24	15,977	801	147,736,123
Sculpin						58	23,006	1,287	24,351
Sea-bass, Black					10	985	111,772	86,101	198,868

Sea-bass, Shortfin								55	55
Sea-bass, White				227	611	18,505	167,608	279,686	466,670
Shark				11,266		640	88,057	14,458	114,421
Sheepshead						591	9,729	831	11,151
Skate				31,0[illegible]	1,135		998		33,153
Smelt	140	3,691		19,0[illegible]	78,[illegible]75	3,179	40,207	6,268	181,483
Sole		56		1,973,7[illegible]	1,511	132,901	1,253	141	2,103,671
Split-tail			300						300
Sucker			1,800						1,800
Swordfish, Broadbill						7,922	126,814	65,765	200,501
Swordfish, Marlin						122	14,698	44,820	59,640
Tomcod				400					400
Tuna, Albacore					715	330	1,494,163	40	1,495,278
Tuna, Bluefin						148	14,552,751	364,203	14,917,102
Tuna, Bonito						9	79,191	297,932	377,132
Tuna, Skipjack							2,751,226	4,734,287	7,485,513
Tuna, Yellowfin							6,243,741	10,896,215	17,139,956
Turbot				3,483					3,483
Whitebait		11,529		4,016	2,128				17,703
Whitefish						101	1,586	8,568	10,255
Yellowtail							304,734	426,151	730,885
Miscellaneous Fish		1,447		51,895	786	133	2,368		56,629
Crustacean:									
Crab	18	22,608		312,792	3,170				338,588
Crab, Rock							6,885		6,885
Lobster, Spiny						10,439	61,263	35,838	137,540
Shrimp				678,272					678,272
Mollusk:									
Abalone					914,425	154,300	725		1,069,450
Clam, Cockle				5,626			2,847		8,473
Clam, Gaper				724					724
Clam, Pismo					2,310	50,422			52,732
Clam, Soft-shell				51,240					51,240
Clam, Washington		6,366		464					6,830
Octopus				771	9,405		2		10,178
Oyster, Eastern				84,871					84,871
Oyster, Native				14,150					14,150
Squid					170,290		31,070		201,360
Reptile:									
Turtle								530	530
Total pounds	67,182	2,423,838	20,467,551	13,459,515	124,757,483	531,973	76,739,054	22,416,663	260,863,259

*Fresh fish importations from foreign countries included. See importation tables.

FRESH FISH IMPORTATIONS* FROM FOREIGN COUNTRIES FOR JULY, AUGUST AND SEPTEMBER, 1934

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

Species of fish	*Landed in Region 70, Los Angeles*	*Landed in Region 80, San Diego*	*Total pounds*
Barracuda	32,333	73,058	105,391
Cabrilla	82,050	10,327	92,377
Corbina, Mexican	75	-------	75
Grouper	12,966	359	13,325
Halibut, California	29,088	96,947	126,035
Mackerel, Pacific	-------	173,020	173,020
Mackerel, Spanish	-------	822	822
Rock Bass	4,713	10,077	14,790
Rockfish	255	13,633	13,888
Sardine	-------	304	304
Sea-bass, Black	109,684	69,517	179,201
Sea-bass, White	99,069	244,486	343,555
Shark	-------	104	104
Sheepshead	-------	160	160
Smelt	-------	1,056	1,056
Swordfish, Broadbill	-------	5,898	5,898
Swordfish, Marlin	85	3,432	3,517
Tuna, Albacore	1,375,620	-------	1,375,620
Tuna, Bluefin	296	26,035	26,325
Tuna, Bonito	6,131	24,336	30,467
Tuna, Skipjack	2,751,226	4,734,287	7,485,513
Tuna, Yellowfin	6,243,661	10,877,387	17,121,048
Whitefish	-------	715	715
Yellowtail	264,330	394,844	659,174
Miscellaneous Fish	93	-------	93
Crustacean—Lobster, Spiny	-------	135	135
Reptile—Turtle	-------	530	530
Total pounds	11,011,669	16,761,469	27,773,138

* This poundage included in tables of landings for Region 70, Los Angeles, and Region 80, San Diego.

FRESH FISH IMPORTATIONS BY POINT OF ORIGIN—JULY, AUGUST AND SEPTEMBER, 1934

Compiled by the Division of Fish and Game, Bureau of Commercial Fisheries

Species of fish	Gulf of California	West Coast Lower California	International waters south U. S. boundary (definite origin unknown)	Mexican mainland and Central America	Japan	Total pounds
Barracuda		18,879	86,512			105,391
Cabrilla		8,099	84,278			92,377
Corbina, Mexican			75			75
Grouper		2,424	10,901			13,325
Halibut, California			126,035			126,035
Mackerel, Pacific			173,020			173,020
Mackerel, Spanish			822			822
Rock Bass		1,000	13,790			14,790
Rockfish		255	13,633			13,888
Sardine			304			304
Sea-bass, Black		19,426	159,775			179,201
Sea-bass, White		1,561	341,994			343,555
Shark			104			104
Sheepshead			160			160
Smelt			1,056			1,056
Swordfish, Broadbill			5,898			5,898
Swordfish, Marlin		85	3,432			3,517
Tuna, Albacore					1,375,620	1,375,620
Tuna, Bluefin			26,325			26,325
Tuna, Bonito		2,087	28,380			30,467
Tuna, Skipjack	187,028	1,921,992	5,085,352	86,159	204,982	7,485,513
Tuna, Yellowfin	504,093	1,178,277	12,094,426	3,343,352		17,121,048
Whitefish			715			715
Yellowtail	9,005	164,552	485,617			659,174
Miscellaneous Fish			93			93
Crustacean:						
Lobster, Spiny			135			135
Reptile:						
Turtle			530			530
Total pounds	701,026	3,318,637	18,743,362	3,429,511	1,580,602	27,773,138

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BUREAU OF PATROL

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K. P. Allred, Assistant Chief of Patrol—San Francisco
C. S. Bauder, Assistant Chief of Patrol—Los Angeles

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McPherson Lough—Palo Alto
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Orben Philbrick—Monterey
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W. J. Black—Vallejo
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Ed Clements—Fairfield
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Nelson Poole—Sacramento Office
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Chas. Sibeck—Sacramento Office
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Scott Feland—Fortuna
Ed Johnson—Garberville
W. F. Kallher—Fortuna

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Brice Hammack—Yreka
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Paul Kehrer—Fall River Mills
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L. W. Dinsdale—Yuba City
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Taylor London—Oroville
E. O. Wraith—Chico

J. D. DONDERO—Lakeport
Ray Diamond—Willits
Ovid Holmes—Fort Bragg
Geo. N. Johnson—Napa
Earl Macklin—Ukiah
L. A. Mitchell—Point Arena
K. J. Ransdell—Lakeport

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J. H. Groves—Cloverdale
V. E. Vox Arx—Santa Rosa

JOSEPH H. SANDERS—Truckee
C. O. Fisher—Susanville
C. L. Gourley—Westwood
L. E. Mercer—Quincy
Alvin Granstrom—Portola

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M. S. Clark—Merced
L. W. Longeway—Sonora
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R. A. Tinnin—Newman

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Wm. Hoppe—Lodi
Vernon Sutton—Angels Camp
J. W. Thornburg—Markleeville

E. W. SMALLEY—Hanford
F. A. Bullard—Reedley
Ray Ellis—Fresno

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Lester Arnold—Bakersfield
Ray J. Bullard—Porterville
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C. L. Savage—Ontario

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C. H. GROAT, Captain—Terminal Island
R. F. CLASSIC, Captain—Monterey
N. C. Kunkel—Terminal Island
T. W. Schilling—San Diego
T. J. Smith—Terminal Island
A. Robertson—Terminal Island

Launch Patrol

Walter Engelke—Motor Vessel "Bluefin," Terminal Island
L. J. Weseth—Launch "Albacore," Monterey
Erol Greenleaf—Launch "Albacore," Monterey
C. M. Bouton—Launch "Quinnat," San Rafael
W. J. Black—Launch "Hunter," Vallejo
Wm. Hoppe—Launch "Rainbow," Walnut Grove
W. J. Harp—Launch "Silverside," Eureka

Captains indicated in capitals.